PROCEEDINGS

OF THE

THIRTY-FOURTH ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

PALMER HOUSE, CHICAGO, ILLINOIS
March 14 and 15, 1933

VOLUME 34

TABLE OF CONTENTS

BUSINESS SESSION

COMMITTEE REPORTS

DISCUSSIONS

BUSINESS SESSION

PROCEEDINGS

The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction and maintenance of Railways. Its action is not binding upon its members.

TUESDAY, MARCH 14, 1933

MORNING SESSION

The Thirty-fourth Annual Convention of the American Railway Engineering Association was called to order in the Grand Ball Room of the Palmer House, Chicago, by the President, Mr. John V. Neubert, Chief Engineer Maintenance of Way, New York Central Railroad.

The President:—I do not know of anything more appropriate than to say "Good Morning!" to you. The meeting will please come to order.

The Thirty-fourth Annual Convention of the American Railway Engineering Association is now declared open for the transaction of business. This is also the annual session of the Construction and Maintenance Section of the American Railway Association, Division IV—Engineering, the meetings being concurrent.

The first order of business is the reading of the Minutes of the last annual meeting. Inasmuch as these Minutes have been printed and a copy furnished to each member, the reading of the Minutes will be dispensed with, if there is no objection. There being no objection, the Minutes will stand approved as printed.

We have a long program before us. We are back to the two-day session, as we had last year. I hope that everyone here feels that the subjects as presented in the Bulletins are worthy of discussion. I also hope that the older members and particularly the younger members will enter into the discussion.

In order to save time, we are not going to have a great many preliminaries. We started this meeting about half an hour late this morning for the reason that changes in certain train schedules made it impossible for some members to get here early. I hope that we can make that time up between now and noon.

Before I make the President's address, which is customary, I want to explain the conditions that arose last week in connection with holding this meeting of the Association. We had some discussion in regard to deferring this meeting, the idea being that by deferring it until later we would have a larger attendance. I held out for holding it on Tuesday and Wednesday. We have been through some pretty trying times. The year past has been trying but pleasant. I may have disappointed a great many of the members by not deferring this meeting. If so, I regret it, but I felt that we should go ahead. The complimentary remarks I have heard in that connection leave me grateful. Do not blame any of the Board or anybody else in regard to carrying on the Association meeting. It was no one but me; I will take the blame. I felt that this Association had gone along for thirty-four years without a break in its meetings and I did not see why we should do it now. I felt that we should stand in the front line and carry on. I think by doing that we are going to get farther ahead. I thought I should make those remarks, so blame me and no one else (Applause).

(President Neubert read his Address, with the following interpolation preceding the poem, "The Guy Who Stubbed His Toe." In closing, I am going out of the usual

realm. I am going to read a poem I have read many times. This poem to me is like a prayer. I have applied it a great many times and I hope you will. I am reading this to you and for those who are out of positions or who have been reduced in pay or working time. I think it is appropriate at this time.)

"THE GUY WHO STUBBED HIS TOE"

Did you ever pass a youngster, who had been an' stubbed his toe,
An' was setting by the roadside, just a-crying soft and low,
A-holdin' of his dusty foot, so hard an' brown and bare,
An' trying to keep back from his eyes, the tears that's a-gatherin' there?

You hear him sorter sobbin' like, an' snifflin of his nose,
You stop an' pat him on the head, an' try to ease his woes.
You treat him sorter kind like, and the first thing that you know,
He's up and off a-smilin', clean forgot he stubbed his toe.

'Long the road of human life you'll find a feller going slow,
An' like as not he's some poor cuss who's been an' stubbed his toe;
He was makin' swimmin' headway 'till he bumped into a stone,
An his friends kept hurryin' onward an' they've left him here alone.

He ain't sobbin' an' ain't snifflin', he's too old for sobs an' cries,
But he's grievin' just as earnest, if it only comes in sighs;
And it does a lot of good sometimes to go a little slow,
And speak a word of comfort to the guy who's stubbed his toe.

You ain't sure yourself, an' there ain't no way to know,
When it's going to come your time to slip and stub your toe.
To-day you're bright and happy in the world's sunlight and glow,
An' tomorrow you're a-freezin' an' a-trudgin' through the snow.

The time you think you've got the world the tightest in your grip,
Is the very time you'll find you're likeliest to slip;
An' it does a lot of good sometimes to go a little slow,
And speak a word of comfort to the guy who's stubbed his toe.

ADDRESS OF PRESIDENT JOHN V. NEUBERT

As we open this, the thirty-fourth Annual Meeting of the American Railway Engineering Association, we have the history of railways for about a hundred years behind us, and it, therefore, seems to me that this is an occasion when it is appropriate to make a short review of the growth and progress of your Association since its organization in 1899.

When your Association was first thought of there was no one who could possibly make the faintest prediction of the wonderful advance that was to be made in the art and science of railroading. The great men in our profession who got together at that time surely had a vision that such an organization as ours would have a great field for work such as they later laid out.

The results up to this date are a conclusive answer. The value of research, standardization, methods, practices, safety arrangements, etc., have meant not only savings to the railroads, but savings and service to all of the people.

The long list of meetings which have been so fully attended, and which have proven valuable and educational to all the members; the Proceedings, with their records of addresses, papers and discussions by men of advanced experience in almost every

branch of railway engineering, the constant growth in the membership of the Association, and its widespread influence all go to indicate that from the beginning it has been an earnest and progressive organization, constantly searching for what is good and true and it has been one of the most important factors in the advance of railway engineering science.

Not only those of us who are counted among its first members, but those who from year to year have been added to its membership, may well be proud of its splendid record.

The scope and influence of our Association, which has been constantly increasing in the past, will surely continue, and never was its future brighter than at present.

At the close of each year in the life of our Association, it is customary to give an accounting of our stewardship of the general affairs of the organization.

Your President will only touch briefly on the high spots, and for details you are referred to the Secretary's report.

(1) *Committee-Work.*—The principal activities of your Association revolve around committee-work. The year just passed has been an unusually difficult period in many respects. Committee-work has been carried on under handicaps brought about by the prevailing adverse business conditions. Members who have heretofore been quite active on committees, have been obliged to curtail attendance at meetings, and, in some instances, to give up entirely participation in committee activities. However, notwithstanding these difficulties, the results of the year's efforts in committee-work have been most gratifying, as will readily appear from a review of the reports submitted for your consideration and action.

(2) *Finances.*—By referring to the Secretary's report, you will note that our financial condition is quite satisfactory, considering the economic conditions.

(3) *Membership.*—It is deeply regretted that business conditions have made it necessary for a considerable number of our members to withdraw their affiliation temporarily. It is earnestly hoped that with a return to normal business activities, we will regain all of these valued members.

We have also sustained a loss of a number of valuable members by death during the year. The Association sincerely mourns their loss.

(4) *Other Activities.*—In July of last year, Mr. R. H. Aishton, President of the American Railway Association, requested answers to the following questionnaire:

(1) Are the maximum results and benefits being obtained from all the Engineering Division's activities at the present time?

(2) Are there any problems with which the Division is now dealing or within the scope of its activities, that merit more intensive investigation and research?

If so, (a) What are such problems?

(b) What is specifically recommended as to research and investigation?

(c) What might be accomplished in the interest of economy and efficiency if such recommended work were undertaken?

The views of present and former chairmen of committees, past and present officers, and of individual members were solicited, and based on the replies received, the following answers were returned to the questionnaire:

(1) Yes. The activities of the Engineering Division have been conducted upon a sound basis, and results of great value to American railways have been accomplished. Research investigations already undertaken will undoubtedly add to the value of the work heretofore done.

(2) The Engineering Division's committees are fully alive to the necessity of completing work on certain controversial matters, and new problems are continually arising. Such new problems are being currently assigned as conditions permit. The most important uncompleted and new problems are as follows:

Construction and Maintenance Section

(a) Further research on the general question of rail.
(b) Stresses in track, including locomotive counterbalancing, and design of track.
(c) Bearing power of soils.
(d) Further tests on impact on bridges.
(e) Further study and research of nickel steels and other alloy metals in structures and equipment.
(f) Study of the economic value of various basic and composite materials used in building construction and maintenance.

Signal Section

(a) Research to develop methods to secure proper shunting of track circuits by light-weight equipment.
(b) Special study of efficiency and economy in the installation, maintenance and operation of signals, interlocking plants, etc.
(c) Investigation and test of reflector signs for highway grade crossing protection and development of plans and specifications to cover.

Electrical Section

(a) Application of electric heat for various purposes.
(b) Proper application of motors, both standard and special.
(c) Servicing equipment along right-of-way for air-conditioning and pre-cooling of cars.
(d) Continue study of corrosion-resisting materials.
(e) Power supply in connection with parking of Pullman cars in other than regular service.

The subjects quoted above were approved by the Board of Directors of the American Railway Association, and have been assigned to the proper committees for study and report.

At the time your Association was founded in 1899, railroads virtually had a monopoly of the transportation of freight and passengers. In the decade following, many new lines were constructed, existing lines extended and facilities expanded to provide for future requirements. Within the last twenty years, however, the entire picture of transportation has changed with the advent of four formidable competing agencies, namely, the private automobile and the motor truck; the airplane; the inland waterways, and the pipe lines.

These active competitors, some subsidized directly or indirectly by the Government, have created a situation seriously affecting railway revenues. We can have no objection to other forms of transportation entering the field, provided they are economically sound, can stand on their own feet, and are subjected to the same regulations as are the railways. We feel confident that railways can hold their own if given as free a hand as is accorded their competitors under similar conditions.

The introduction of these several forms of transportation has naturally created new problems, and various groups and individuals are giving intensive study to the question of co-ordinating the new modes of transport in order that the public may be well served.

Your Association will have a prominent part in the solution of some of these problems, and it can be safely assumed that it will adequately fulfill this important mission.

In the past year we had twenty-six standing and three special committees; twenty-nine in all. To these committees there are 240 subjects assigned, of which the number of subjects reported in the 1932 Bulletins are 146.

Approximately one-third of the entire membership of the Association serves on one or more committees, and I believe I am correct in stating that this is the largest proportion of representative membership serving its Association in any similar organization in the United States or in European countries.

Besides this, we have committees collaborating between one another on sixty-four subjects.

In view of probable future changes and carrying out in our own minds the thought of preparing ourselves for such changes in the application and use of engineering and maintenance, I have the following suggestions to make for consideration:

Combining the work of Committee I—Roadway, with Committee II—Ballast.

Combining the work of Committee III—Ties, with that of Committee XVII—Wood Preservation.

Combining the work of Committee VII—Wooden Bridges and Trestles, with that of Committee XV—Iron and Steel Structures.

Combining the work of Committee XI—Records and Accounts, with that of the work of Committee XX—Uniform General Contract Forms.

The possibility of having Committee VI—Buildings, handle the work of engine houses and locomotive terminal buildings, which is now under the jurisdiction of Committee XIV—Yards and Terminals.

Either broaden the work of Committee XXVI—Standardization, or have another committee to be a clearing house to make a survey of the findings or high spots of the various groups, and indicate the relationship which exists between the findings of one group and the findings of another group, or all groups.

Individual research is, of course, valuable, but the trouble is that few men have the time (or ability) to put together the results of detailed efforts.

Of course, we should guard ourselves against the possibility of making the membership of each committee too great, or on the other hand, denying a great many members the opportunity of serving on committees, which might weaken the interest somewhat in the Association's work. Still, I think this could be worked out without objection.

I feel that your Association is the greatest of its kind in existence, not only because it undertakes investigations and scientific research in regard to plans and specifications, but also makes further study and research relative to the application and use of the same, and this is done prior to anything being adopted as recommended practice by your Association.

With this in view, I feel that a more general adoption of the recommended practices and standards of your Association should be urged and put into effect on every road possible in the interest of efficiency and economy of the railways in general.

One of the problems with which we have been confronted in keeping up with the advance in transportation is the increase of axle loads which have affected track and structures as a whole. I believe the tendency will be toward lighter axle loads, with more uniform loads, which will aid and assist in working out our fixed general standards in the construction and maintenance field.

We have heard the expression quite frequently that we are living in a machine age, but the machine cannot be blamed justly for everything we do not like in our lives. The world needs more machines—not less, but it needs to co-ordinate its affairs so that every new machine will be made to serve, and not harm men.

We are all a part of an international world whose tariffs, currencies and customs affect our own, and due to a lack of co-ordination between us, we are continually interfering with each other's lives in a way which ultimately brings evil to all of us.

I am not referring to co-operation. There is a vast difference. This reminds me of an Italian boy who was selected to make a speech in a public school. Father Maloney was going to be present, and all aunts and uncles. It was a great occasion, but, alas, it was discovered that the boy's trousers were frayed and full of holes. There was no money in the family treasury. Finally, after a conference of the entire family, it was suggested that father's trousers might do if rolled up at the bottom. Picturing himself standing before the audience in his father's trousers rolled up filled the boy with alarm. However, the family council ruled it was the best they could do under the circumstances. The family retired for the night worried and distressed. As the night wore on the sleepless mother thought: "I might slip down and cut off six inches off those trousers and no one would know who did it, and I would not be blamed, and the boy would be spared the disgrace of wearing his father's trousers rolled up", and she acted accordingly. Meanwhile, the sister was worrying about the same problem. With the desire to co-operate with her brother, she thought, "I might cut off six inches from the bottom of father's trousers and no one would know who did it, and brother would not have to wear them rolled up". So just before dawn, she arose and proceeded to sheer six inches from the shortened trousers. In the morning it was evident that there had been co-operation without co-ordination, because the trousers then reached just a few inches below the knees of the boy.

* * *

A year ago you honored me by election as President of your Association. In accepting office, I expressed confidence of your support in "carrying on." I have had many occasions to observe how efficiently the splendid organization which controls your affairs has performed the various duties involved in the development and management of an engineering society. The loyalty and great interest of the members generally have been the vital force guiding the administrative work of the Board of Direction and the committees.

I now desire to express my obligation to my associates, the committee membership, and the members at large for their helpfulness in aiding me in the discharge of my duties. It only remains for me to say that I am extremely grateful for your consideration and helpfulness, and I am amply repaid if what I have said has been illustrative and interesting to you. (Applause.)

The President—The next reports we have are those of the Secretary and the Treasurer. Mr. Fritch, please.

(Secretary Fritch read the reports of the Secretary and of the Treasurer.)

REPORT OF THE SECRETARY

March 1, 1933.

To the Members:

At the close of another year, it seems proper and fitting to briefly review what has been accomplished during that period.

Committee-Work.—The results of the major activities carried on during the year are recorded in the series of excellent reports submitted for your consideration and action at the annual meeting. Notwithstanding the unusual business conditions which have prevailed during the past year, and which have naturally affected committee-work, reports of outstanding value and of timely interest have been formulated by the various committees, and you have been well served in this respect.

Elsewhere in this report is a synopsis of the principal subjects on which reports have been rendered. It is of interest to note that a total of 157 subjects are dealt with in these reports.

Outside Activities.—Contact with various organizations has been maintained, among them being the following: American Railway Association, American Standards Association, American Society of Civil Engineers, American Society for Testing Materials, Central Committee on Lumber Standards, Chemical Warfare Service of the U. S. Army, Chicago Engineering Council, Highway Research Board of the National Research Council, Committee on Automatic Train Control, Joint Committee on Concrete and Reinforced Concrete, Joint Committee on Grade Crossing Protection, Joint Committee on Railway Sanitation, Manganese Track Society, National Scalemen's Association, Portland Cement Association, Rail Manufacturers' Technical Committee, University of Illinois Experiment Station, National Bureau of Engineering Registration.

Publications.—The customary number of Bulletins and Proceedings were issued during the year. In addition to the publication of committee reports, the Bulletins contained a number of valuable contributions from members on timely and interesting subjects, as follows: "Review of the Performance of Steel Rails in American Railways," by C. W. Baldridge; "The Theory of Probability Applied to Bridge and Building Loadings," by B. R. Leffler; "The Railroads—in Retrospect, in Prospect," by L. C. Fritch; "Rail Gage Plate, Adopted by the Southern Pacific Company, Pacific Lines," by W. H. Kirkbride.

Membership.—It is a matter of deep regret that it is necessary to record a loss in membership from the number reported on a year ago. This situation is due solely to economic conditions, but is hoped that when conditions improve, the losses sustained will be more than regained.

The Board of Direction has taken sympathetic action in the case of members unable to meet their obligations during this critical period.

The status of the membership as of March 1, 1933, is as follows:

Members on rolls as of March 1, 1932		2723
Additions during the year		30
		2753
Losses by death	32	
Resigned	156	
Dropped	218	
Suspended	36	442
Membership as of March 1, 1933		2311

Deceased Members.—The losses sustained by death during the year are recorded on following pages. Our departed associates materially aided in promoting the welfare of the Association, and their passing is deeply regretted.

Geographical Distribution of the Membership.—On one of the following pages is an interesting table, showing the wide distribution of the membership of the Association.

Finances.—It is a matter of congratulation that the Association has come through the year with a comfortable margin of excess of receipts over disbursements. The financial statement appended to this report gives in detail the financial status for the calendar year 1932.

Vacancy in Board of Direction.—The vacancy in the Board of Direction, created by the death of E. A. Hadley, has been filled by the unanimous election, by the Board of Direction, of A. R. Wilson, Engineer Bridges and Buildings, Pennsylvania Railroad, Chairman of the Committee on Iron and Steel Structures.

In Conclusion.—Scientific societies, such as the American Railway Engineering Association, supply the needed facilities for the members to discuss their investigations, compare their experiences, and to place their data on record, where they are accessible to any Engineer for utilization in any part of the world.

The social influences naturally following the frequent meeting face to face of earnest men, sweeps away a host of fancied differences, leading the way step by step to mutual helpfulness and cooperation.

The influential position now held by the Association came not by happy accident, but by the earnest work of men who stamped their own character upon it, for your Association, like all human institutions, is what its members have made it. If it has high ideals, it is because its members cherished such ideals in their thoughts—they hoped for their realization, and, finally, by well-directed efforts, saw them crystallize in this organization.

Secretary.

Railway Executives on Membership Rolls.—It is particularly gratifying to record the continued affiliation of Railway Executives on our rolls, as exemplified in accompanying table.

Atchison, Topeka & Santa Fe	W. B. Storey, President
Atlanta, Birmingham & Coast	B. L. Bugg, President
Atlantic Coast Line	L. Delano, Chairman of Board
	G. B. Elliott, President
Baltimore & Ohio	Daniel Willard, President
Baltimore & Ohio Chicago Terminal	H. B. Voorhees, President
Boston & Maine	E. S. French, President
Canadian National	S. J. Hungerford, Chairman and President
Canadian Pacific	E. W. Beatty, Chairman and President
Central of Georgia	H. D. Pollard, Receiver
Central of New Jersey	W. G. Besler, Chairman of Board
	R. B. White, President
Chicago, Burlington & Quincy	Ralph Budd, President
Chicago, Rock Island & Pacific	J. E. Gorman, President
Chicago & Eastern Illinois	C. T. O'Neal, President
Colorado & Wyoming	Arthur Roeder, President
Delaware, Lackawanna & Western	J. M. Davis, President
Dominion Atlantic	Grant Hall, President
Elgin, Joliet & Eastern	S. M. Rogers, President
Erie	C. E. Denney, President
Eureka Nevada	J. H. Sherburne, President
Huntingdon & Broad Top Mountain	J. Bancroft, President
Illinois Central	L. A. Downs, President
Jacksonville Terminal	J. L. Wilkes, President
Kansas City Southern	C. E. Johnston, President
Kansas City Terminal	P. J. Watson Jr., President and General Superintendent
Lehigh Valley	E. E. Loomis, President
Louisville & Nashville	W. R. Cole, President
Minneapolis, St. Paul & Sault Ste. Marie	C. T. Jaffray, President
Missouri–Kansas–Texas	M. H. Cahill, Chairman and President
Missouri Pacific	L. W. Baldwin, President
Mobile & Ohio	E. E. Norris, Receiver
Montana, Wyoming & Southern	W. H. Bunney, President and General Manager
New York Central Lines	F. E. Williamson, President
New York, Chicago & St. Louis	W. L. Ross, President (retired)
New York, New Haven & Hartford	J. J. Pelley, President
New York, Ontario & Western	J. H. Nuelle, President
Northern Pacific	Charles Donnelly, President
Norfolk & Western	A. C. Needles, President
Pennsylvania System	W. W. Atterbury, President
Peoria & Pekin Union	E. I. Rogers, President
Reading	C. H. Ewing, President
Sand Springs Railway	T. H. Steffens, President
Savannah & Atlanta Railway	C. E. Gay, Jr., Receiver and General Manager
St. Louis–San Francisco	J. M. Kurn, Receiver
St. Louis!Southwestern Railway	Hale Holden, Chairman of Board
	A. D. McDonald, Chairman, Executive Committee
Seaboard Air Line	L. R. Powell, Receiver
Southern Railway System	Fairfax Harrison, President
Southern Pacific	Hale Holden, Chairman Executive Committee
	A. D. McDonald, President
Tennessee, Alabama & Georgia	G. H. Burgess, President
Tennessee Central	H. W. Stanley, President
Terminal Railroad Assn. of St. Louis	Henry Miller, President
Toledo Terminal	A. B. Newell, President
Union Pacific	Carl R. Gray, President
Western Pacific	T. M. Schumacher, Chairman Executive Committee

Deceased Members

L. L. Beall
Chief Engineer, Atlanta, Birmingham & Coast Railroad

Miles Bronson
Retired Terminal Engineer, New York Central Railroad

E. B. Brooks
Assistant Engineer, New York Central Railroad

G. M. Callahan
Assistant Engineer, New York Central Lines

O. P. Chamberlain
Vice-President, Dolese & Shepard Company

C. J. Chase
Assistant Engineer, Boston & Maine Railroad

W. C. Coles
Office Engineer, Baltimore & Ohio Railroad

J. B. Cox
Consulting Engineer; Charter Member

B. V. Davis
Division Engineer, Chesapeake & Ohio Railway

A. T. Dice
President, Reading Company

E. F. Gorman
Resident Engineer, Reading Company

E. W. Grant
Civil Engineer

E. A. Hadley
Chief Engineer, Missouri Pacific Railroad; Director, American Railway Engineering Association; Chairman, Committee on Rivers and Harbors; Chairman, Committee on Automatic Train Control, American Railway Association

L. C. Hartley
Retired Chief Engineer, Chicago & Eastern Illinois Railway

F. E. Hatch
Superintendent, Illinois Central System

B. O. Johnson
Retired Vice-President-Operation, Northern Pacific Railway

Deceased Members

R. Kohler
Civil Engineer; Charter Member

A. C. Mackenzie
Engineer Maintenance of Way, Canadian Pacific Railway

J. R. C. Macreadie
District Engineer, Canadian Pacific Railway

J. E. McMahon
Superintendent, Atchison, Topeka & Santa Fe Railway

J. G. Meenan
Roadmaster, Trinity & Brazos Valley Railway

J. L. Miller
Engineer of Bridges, New York Central Railroad

A. J. Neafie
Principal Assistant Engineer, Delaware, Lackawanna & Western Railroad

J. N. Pariseau
Chief Draftsman, Northern Pacific Railway

F. J. Reinke
Chief Engineer, St. Louis Material & Supply Company

H. H. Robinson
Roadmaster, Portland Terminal Company

S. A. Seely
Division Engineer, New York Central Railroad

P. B. Spencer
Engineer of Structures, New York, New Haven & Hartford Railroad

J. D. Wardle
Chief Engineer, Cedar Rapids & Iowa City Railway

J. T. Westbrook
Assistant Engineer, Illinois Central System

C. V. Weston
Consulting Engineer, Chicago Surface Lines

M. A. Zook
President, Montana, Wyoming & Southern Railroad

GEOGRAPHICAL DISTRIBUTION OF MEMBERSHIP

United States and Possessions

Alabama	8	Nebraska	33
Arizona	3	New Hampshire	6
Arkansas	26	New Jersey	43
California	61	New Mexico	1
Colorado	14	New York	200
Connecticut	25	North Carolina	17
Delaware	1	North Dakota	1
District of Columbia	29	Ohio	164
Florida	19	Oklahoma	13
Georgia	26	Oregon	4
Hawaii	1	Pennsylvania	177
Idaho	4	Philippine Islands	2
Illinois	313	Puerto Rico	1
Indiana	37	Rhode Island	3
Iowa	17	Tennessee	18
Kansas	43	Texas	92
Kentucky	30	Utah	8
Louisiana	19	Vermont	7
Maine	11	Virginia	100
Maryland	48	Washington	25
Massachusetts	55	West Virginia	23
Michigan	48	Wisconsin	10
Minnesota	70	Wyoming	1
Mississippi	10		
Missouri	174		2050
Montana	9		

Other Countries

Canada	125	Colombia	2
Japan	28	Germany	2
Mexico	15	Siam	2
Union Soc. Sov. Republics	12	Bolivia	1
China	11	Egypt	1
Argentine	8	France	1
Australia	8	Jamaica	1
Brazil	8	Korea	1
England	6	Scotland	1
Manchuria	6	Spanish Honduras	1
Central America	5	Sudan	1
Cuba	5	Switzerland	1
India	5		
Africa	2		261
Czecho-Slovakia	2		

Railways Represented, Mileage and Number of Members.— Statistics covering this feature are given in the following table.

RAILWAYS REPRESENTED IN THE A.R.E.A., MILEAGE AND NUMBER OF MEMBERS

	Mileage	*Number of Members*
Akron, Canton & Youngstown Railway	171	1
Algoma Central & Hudson Bay Railway	323	1
Alton & Southern Railroad	22	1
Arkansas Railroad Company	20	1
Arkansas & Louisiana Missouri Railway	85	1
Atchison, Topeka & Santa Fe Railway System	13,568	72
Includes Gulf, Colorado & Santa Fe Panhandle & Santa Fe		
Atlanta, Birmingham & Coast Railroad	637	3
Atlanta & West Point Railroad	227	1
Atlantic Coast Line Railroad	5,317	17
Baltimore & Ohio Railroad System	5,640	86
Alton Railroad	1,052	5
Bangor & Aroostook Railroad	619	2
Bessemer & Lake Erie Railroad	228	6
Bingham & Garfield Railway	40	1
Boston & Maine Railroad	2,090	28
Brantford Steam Railroad	....	1
Brooklyn Manhattan Transit Corporation	9	1
Burlington-Rock Island Railroad	367	1
Butte, Anaconda & Pacific Railway	65	1
Canadian National Railways	21,926	59
Central Vermont Railway	462	2
Grand Trunk Western Railway	1,448	8
Canadian Pacific Railway	16,040	35
Central of Georgia Railway	2,021	15
Central Railroad of New Jersey	693	13
Chesapeake Beach Railway	28	1
Chesapeake & Ohio Railway	3,120	88
Chicago & Eastern Illinois Railway	946	5
Chicago, Burlington & Quincy Railroad	9,325	24
Chicago Great Western Railroad	1,495	7
Chicago, Indianapolis & Louisville Railway	652	3
Chicago, Milwaukee, St. Paul & Pacific Railroad	11,353	29
Chicago Railway Terminal Commission	....	1
Chicago Rapid Transit Company	....	2
Chicago, Rock Island & Pacific Railway	7,592	44
Chicago, St. Paul, Minneapolis & Omaha Railway	1,747	2
Chicago Union Station Company	....	1
Chicago, West Pullman & Southern Railroad	31	1
Chicago & Illinois Midland Railway	132	1
Chicago & Northwestern Railway	8,462	14
Chicago & Western Indiana Railroad	71	8
Cincinnati, New Orleans & Texas Pacific Railway	338	1
Cincinnati Union Terminal Company	....	5
Cleveland Union Terminals Company	60	2
Colorado & Southern Railroad	1,038	1
Colorado & Wyoming Railroad	40	1
Columbia & Cowlitz Railway	8	1
Danville & Western Railroad	83	1
Delaware & Hudson Company	924	13
Delaware, Lackawanna & Western Railroad	998	22
Denver & Rio Grande Western Railroad	2,562	3
Des Moines Union Railway	28	1
Detroit & Toledo Shore Line Railroad	50	3
Detroit, Toledo & Ironton Railroad	509	2
Dominion Atlantic Railway	305	1
Duluth, Missabe & Northern Railway	568	6
Elgin, Joliet & Eastern Railway	453	5
Erie Railroad	2,560	34
Eureka Nevada Railway	88	1
Florida East Coast Railway	869	9
Fort Smith & Western Railway	250	1
Fort Worth & Denver City Railway	697	2
Georgia & Florida Railroad	502	1
Georgia Railroad	329	1
Great Northern Railroad	8,605	17
Gulf, Mobile & Northern Railroad	733	1
Houston Belt & Terminal Railroad	24	1
Hudson & Manhattan Railroad	9	1

	Mileage	Number of Members
Huntingdon & Broad Top Mountain Railroad & Coal Company	74	1
Illinois Central System	6,762	67
Illinois Terminal Railroad System	578	4
Indianapolis Union Railway	16	2
Interborough Rapid Transit Company	....	3
Interstate Railway	74	1
Jacksonville Terminal Company	51	1
Kansas City Southern Railway	916	15
Kansas City Terminal Railway	26	4
Kentucky & Indiana Terminal Railroad	8	1
Key System Transit Company	135	1
Lake Superior & Ishpeming Railroad	161	1
Lehigh & Hudson River Railway	97	1
Lehigh & New England Railroad	217	4
Lehigh Valley Railroad	1,362	11
Los Angeles Junction Railway	8	1
Louisiana, Arkansas & Texas Railway	202	1
Louisiana & Arkansas Railway	608	2
Louisville & Nashville Railroad	5,280	14
Maine Central Railroad	1,121	8
Mexican Railway	486	1
Midland Continental Railroad	69	1
Midland Valley Railroad	363	1
Minneapolis & St. Louis Railroad	1,627	2
Minneapolis, St. Paul & Sault Ste. Marie Railway	4,397	8
Minneapolis Street Railway Company	....	1
Minnesota Transfer Railway	140	1
Mississippi Central Railroad	150	1
Missouri & North Arkansas Railway	368	1
Missouri–Kansas–Texas Lines	3,189	31
Missouri Pacific Lines:		
Gulf Coast Lines	1,173	16
International Great Northern Railroad	1,160	10
Missouri–Illinois Railroad	202	3
Missouri Pacific Railroad	7,451	127
Mobile & Ohio Railroad	1,159	3
Montana, Wyoming & Southern Railroad	34	1
Montour Railroad	57	2
Montreal Tramways Company	....	1
Muncie & Western Railroad	4	1
Nashville, Chattanooga & St. Louis Railway	1,203	4
National Railways of Mexico	6,920	9
Newburgh & South Shore Railway	83	1
New Orleans & Lower Coast Railroad	60	1
New York Central Lines:		
Boston & Albany Railroad	410	11
Cleveland, Cincinnati, Chicago & St. Louis Railway	2,745	34
Indiana Harbor Belt Railroad	120	2
Michigan Central Railroad	1,858	15
Peoria & Eastern Railway	211	2
Pittsburgh & Lake Erie Railroad	231	3
New York Central Railroad	5,743	82
Nicholas, Fayette & Greenbrier Railroad	....	1
New York, Chicago & St. Louis Railroad	1,698	18
New York, New Haven & Hartford Railroad	2,133	29
Connecticut Company	....	1
New York, Ontario & Western Railway	569	4
Niagara Junction Railway	6	1
Norfolk & Western Railway	2,240	20
Norfolk Southern Railway	933	3
Northern Pacific Railway	6,962	41
Northwestern Pacific Railroad	440	3
Oklahoma Railway	155	1
Oregon & Northeastern Railroad	51	1
Pennsylvania Railroad	10,525	73
Long Island Railroad	404	5
Peoria & Pekin Union Railway	168	2
Pere Marquette Railway	2,265	13
Piedmont & Northern Railway	175	1
Pittsburgh & West Virginia Railway	135	1
Pittsburgh, Chartiers & Youghiogheny Railway	23	1
Pittsburgh, Lisbon & Western Railroad	23	1
Pullman Railroad	6	1
Public Service Railroad of New Jersey	40	1
Quanah, Acme & Pacific Railway	126	1
Reading Company	1,644	28
Atlantic City Railroad	164	1
Richmond, Fredericksburg & Potomac Railroad	118	2
Rio Grande & Eagle Pass Railway	25	1

	Mileage	Number of Members
Rutland Railroad	413	2
Sacramento Northern Railroad	274	1
Sand Springs Railway	32	2
San Francisco, Napa & Calistoga Railway	46	1
Savannah & Atlanta Railway	147	1
Seaboard Air Line Railway	4,492	15
Southern Railway System	8,051	30
New Orleans & Northeastern Railway	202	1
Southern New England Railroad	....	1
Southern Pacific System	9,130	36
Southern Pacific Company of Mexico	1,370	4
Southern Pacific Lines in Texas & Louisiana	4,722	10
Houston & Texas Central Railroad	....	1
St. Louis–San Francisco Railway	5,811	8
St. Louis Southwestern Railway	1,914	11
Tela Railroad	244	2
Temiskaming & Northern Ontario Railway	443	1
Tennessee, Alabama & Georgia Railway	95	1
Tennessee Central Railway	296	1
Tennessee Coal, Iron & Railroad Company	....	1
Terminal Railroad Association of St. Louis	62	4
Texarkana & Fort Smith Railway	81	1
Texas & Pacific Railway	1,955	12
Texas Pacific–Missouri Pacific Terminal Railroad of New Orleans	10	2
Toledo & Western Railroad	79	1
Toledo, Peoria & Western Railroad	239	1
Toledo Terminal Railroad	29	3
Toronto, Hamilton & Buffalo Railway	111	1
Toronto Harbor Commission	....	1
Toronto Terminals Railway	....	3
Union Pacific System:		
Los Angeles & Salt Lake Railroad	1,230	7
Oregon Short Line Railroad	2,549	4
Oregon–Washington Railroad & Navigation Company	2,365	1
Union Pacific Railroad	3,765	25
Union Railroad (Pittsburgh)	46	2
Union Terminal Company (Dallas)	16	1
Utah Railway	111	1
Virginian Railway	562	6
Wabash Railway	2,524	45
Ann Arbor Railroad	294	6
Washington, Idaho & Montana Railway	50	1
Washington Terminal Company	2	1
Waterloo, Cedar Falls & Northern Railway	113	1
Western Maryland Railroad	896	11
Western Pacific Railroad	1,052	4
Wheeling & Lake Erie Railway	537	6
Yosemite Valley Railroad	78	1

Personnel of Committees by Railways—1932

	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Uniform General Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Rivers and Harbors	Standardization	Maintenance of Way Work Equipment	Stresses in Railroad Track	Clearances	Waterproofing of Railway Structures	TOTAL
Ann Arbor																					1									1
Atchison, Topeka & Santa Fe	3	2	2	2	1	1		3	1	1		1	2	1	1		1	1		1	2	1		1	1	1		1	1	32
Atlanta, Birmingham & Coast		1																												1
Atlantic Coast Line	1			1							1				1				2					1		1	1			9
Baltimore & Ohio	2	1		2	1	2	1	2	1	1	1	1	2	1	2	1	1	2	1	4	3	1			3	2	2	2		42
B. & O. Chicago Terminal			1						1																					2
Belt Railway					1																									1
Bessemer & Lake Erie	1										1					1				1		1			1					6
Boston & Maine	2	1		1		1		1			2	1		2			1	1		1	1			1	1	2				19
Canadian National			1	2	3			1		1		1		1	1		1	1	1	3		2			1	1				21
Grand Trunk Western								1			1																			2
Canadian Pacific	1	1	1	1	1	1		1		1		1	1	1	1	1	1					1	1			1		1		18
Central of Georgia			1	1		1											1		1		1			1						7
Central of New Jersey								1	1		1			1				2	1	1										8
Chesapeake & Ohio	2	3	2	3	4	2	2	1	2		5	2	3	1	1	2	1		1	4	2	3	1	1	2	3		1	1	55
Chicago & Eastern Illinois										1					1							1								3
Chicago & Northwestern	1	1		1	1					1	1	1	1		1			1		1						1			1	13
Chicago & Western Indiana									1													1								2
Chicago, Burlington & Quincy	2		2	2	3		1	1	2			1	1		1		1			1	1	1							1	21
Chicago Great Western							1									1														2
Chicago, Indianapolis & Louisville										1	1											1								3
Chicago, Mil. St. Paul & Pacific			1	1		1	1		1		1						1				1	2	1	1		2				14
Chicago, Rock Island & Pacific	1	2		2	2	1		2	2	1	1	2	3		1		2					1	2	1	1		1		1	29
Chicago Rapid Transit								1																						1
Cleveland Union Terminals																		1												1
Cincinnati Union Terminals														1																1
Colorado & Southern									1																					1
Columbia & Cowlitz							1																							1
Columbus & Greenville											1																			1
Delaware, Lackawanna & Western		1	1	1	1		1	1	1				1					1	1	1	1		1			1	1	1		16
Delaware & Hudson														1						1			1		1			1		6
Detroit Rapid Transit									1																					1
Detroit & Toledo Shore Line											1																			1
Denver & Rio Grande Western							1					1																		2
Duluth, Missabe & Northern							1				1													1						3
Elgin, Joliet & Eastern					1																	1				1				

	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Uniform General Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Rivers and Harbors	Standardization	Maintenance of Way Work Equipment	Stresses in Railroad Track	Clearances	Waterproofing of Railway Structures	TOTAL
ie.	2	2			1	1		1	1		1		1	2	1	2			1		1	1		2		1	1		1	23
orida East Coast	2				1		1		1			1			1									1						8
reat Northern	1		1			1	1						1		1		1													7
linois Central	1	1		2	3	1	1		1	2	1	4	2	2			2	2	2	1	2	1	1		3	3			1	39
linois Terminal														1																1
ndianapolis Union														1																1
nterborough Rapid Transit					1																									1
acksonville Terminal														1																1
ohnstown & Stony Creek					1																									1
Kansas City Southern	1	1	1	1							1		1		1					2	1		1	1						12
Kansas City Terminal										1				1																2
Lake Superior & Ishpeming			1																					1						2
Lehigh Valley		1					1	1				1			1											1				6
Louisville & Nashville	2		1	1	1			1																						6
Maine Central	1					1																				2			1	5
Minneapolis & St. Louis																										1				1
Missouri-Kansas-Texas	1	1	1	1		1		1	1		1		2		1						1	1			2	1		1		17
Missouri Pacific Lines	1	1	1			1			1	2	1	1					1		1		1				1		1	1		16
Missouri Pacific Railroad	4		1	1	1	1	3	2	1		2	1	4	3		1			1	1			1	3	3	3	1		1	38
Mobile & Ohio							1																		1			1		3
Newburgh & South Shore			1																											1
New York, Chicago & St. Louis															1				1		1									3
Nashville, Chattanooga & St. Louis					1																									1
New York, Ontario & Western											1																			1
New York Central Lines				1										1		1		1									1			5
Boston & Albany						1			1										1						1					4
Big Four	1		1						1		1				2	1					1	1				1				10
Michigan Central	1	2			2		1		1	1	1			1				1			1					1				13
New York Central Railroad	2	3	3	1	2				3	2	1	2	2		3		3	2	1	1	2	2		1	1	5	1	2	1	46
Nicholas, Fayette & Greenbriar					1																									1
Peoria & Eastern																			1	1										2
Pittsburgh & Lake Erie	1															1														2
New York, New Haven & Hartford				1		2			1	1	2			2	1			1		1	1		1		1	1		1	1	18
Connecticut Company											1																			1
Norfolk & Western	1			1	1	1		1	1				2	1	1			1				1	1	1					1	15

Personnel of Committees by Railways—1932

	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Uniform General Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Rivers and Harbors	Standardization	Maintenance of Way Work Equipment	Stresses in Railroad Track	Clearances	Waterproofing of Railway Structures	TOTAL
Norfolk Southern											1								1						1					3
Northern Pacific			1	1	1	1		1	2			1	2			2	2			2	1				1					18
Pennsylvania		3	3	3	3			2	1	2	2	1	3	2	1	2	2	2	2	2	1		1		1	2	2	1		44
Pere Marquette	1				1				1		1				1						1					1				7
Pittsburgh, Chartiers & Youghiougheny											1																			1
Pittsburgh & West Virginia								1																						1
Reading		1		1	1	1		1	1		1		1		1	1		1							1	1				13
Richmond, Fredericksburg & Potomac														1						1										2
Rutland									1																					1
St. Louis-San Francisco	1																				1									2
St. Louis Southwestern											1		1		1								1							4
Seaboard Air Line										1									1				1	1						4
Southern	1	1		1	2					1		1	1						1	1			1							11
Soo Line																	1									1				2
Southern Pacific (Northwestern Pacific)	2	1	1	1	1		1	1	2	1				1		1	3	1		1	1		2	1	1	1		1		25
Temiskaming & No. Ontario			1																											1
Term. R. R. Assn. of St. Louis					1																									1
Texas & Pacific													1													1				2
Texas Pacific—Missouri Pacific Terminal																				1		1								2
Third Avenue Railway					1																									1
Toronto Terminals														1											1					2
Union Pacific	1			2			1			1			1		1						1					1				9
Union Railway (Memphis)			1																											1
Union Railway (Pittsburgh)								1																						1
United Railway & Electric Co.			1																											1
Utah																						1								1
Wabash			1			2	1		2		1	1	2	2		1				1	1									15
Wheeling & Lake Erie		1					1																							2
Western Maryland									1					1																2
Non-Railroad	2	4	1	2	10	4	2	12	4		3	2	1	15	14	6	12		4	8	1	3	11	2		1	10		3	137
Foreign			1												1					1										3
Total	46	36	35	41	56	29	25	42	44	23	44	28	42	49	45	25	38	22	26	44	33	29	29	22	30	45	22	14	15	1116

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1932

Balance on hand January 1, 1932 .... $66,471.31

RECEIPTS

Membership Account		
Entrance Fees	$ 400.00	
Dues	19,952.04	
Binding Proceedings	1,806.98	
Badges	3.50	
Sales of Publications		
Proceedings	1,495.25	
Bulletins	1,425.84	
Manual	677.45	
Specifications	443.20	
Track Plans	130.00	
Advertising		
Publications	1,189.60	
Interest Account		
Investments	2,645.57	
Bank Balance	70.92	
Miscellaneous	117.91	
Total	$30,358.26	

DISBURSEMENTS

Salaries	$ 8,595.42	
Proceedings	4,588.67	
Bulletins	5,704.46	
Track Plans	1,307.17	
Stationery and Printing	728.62	
Equipment	118.56	
Rents, Light, etc.	830.00	
Supplies	32.77	
Expressage	236.58	
Postage	626.35	
Exchange	81.77	
Committee Expenses	54.80	
Officers' Expenses	42.50	
Annual Meeting	975.81	
Refunds, Dues, etc.	28.50	
Audit	200.00	
Pension (A. K. Shurtleff)	1,200.00	
Miscellaneous	49.97	
Total	$25,401.95	
Excess of Receipts over Disbursements		$ 4,956.31
Balance on hand December 31, 1932		$71,427.62

Consisting of

Bonds	$67,316.02
Cash in City National Bank	2,859.15
Cash in Royal Bank of Canada	1,227.45
Petty Cash	25.00
	$71,427.62

REPORT OF THE TREASURER

Balance on hand January 1, 1932		$66,471.31
Receipts during 1932	$30,358.26	
Paid out on Audited Vouchers, 1932	25,401.95	
Excess of Receipts over Disbursements		$ 4,956.31
Balance on hand December 31, 1932		$71,427.62
Consisting of Bonds at Cost	$67,316.02	
Cash in City National Bank	2,859.15	
Cash in Royal Bank of Canada	1,227.45	
Petty Cash Fund	25.00	
	$71,427.62	

STRESSES IN TRACK FUND

Balance on hand January 1, 1932	$ 5,482.61
Received from Interest during 1932	43.11
Total	$ 5,525.72
Paid out on Audited Vouchers during 1932	2,313.97
Balance of fund on hand December 31, 1932	3,211.75

The Securities listed above are in a Safety Deposit Box of the City National Bank & Trust Company.

Respectfully submitted,

A. F. Blaess, *Treasurer.*

I have made an audit of the accounts of the American Railway Engineering Association for the year ending December 31, 1932, and find them to be in accordance with the foregoing Financial Statements.

Charles Campbell, *Auditor.*

GENERAL BALANCE SHEET

December 31, 1932

Assets	1932	1931
Due from Members	$ 5,487.96	$ 6,242.50
Due from Sales of Publications	201.25	187.85
Due from Advertising	120.00	160.00
Due from Rail Investigations	691.50	753.75
Furniture and Fixtures	506.00	569.00
Gold Badges	40.00	42.50
Publications on hand (Estimated)	2,000.00	3,000.00
Manual (1929)	1,700.00	3,712.00
General Index		3,269.89
Extensometers	400.00	450.00
Investments (Cost)	67,316.02	57,411.02
Interest on Investments (Accrued)	542.79	421.24
Cash in City National Bank & Trust Company	2,859.15	9,035.29
Cash in Royal Bank of Canada	1,227.45	
Petty Cash	25.00	25.00
Total	$83,117.12	$85,280.04

Liabilities	1932	1931
Member's Dues paid in advance	$ 4,356.50	$ 5,690.00
Surplus	78,760.62	79,590.04
Total	$83,117.12	$85,280.04

SYNOPSIS OF COMMITTEE REPORTS

Committee on Roadway (C. W. BALDRIDGE, *Chairman*).—Consideration of the subject of roadbed drainage has been continued in accordance with the outline adopted in 1931, the present report dealing with French or rock drains. The prevention of soft spots and water pockets is dealt with comprehensively . . . . The Committee has also made a study of the service life of fence wire and specifications for railway fence wire. . . . An interesting report is presented on the use of portable cribbing in place of rigid retaining walls and the utility of the different kinds of cribbing, illustrating a number of typical installations. . . . In connection with the subject of the physical properties of soils and their effect on roadbed performances, the Committee states it is undertaking a review of available data on the physical characteristics of soils as found in natural deposits and as disturbed from their natural position to form embankments. . . . Continuing its study of drainage areas and water run-off and the proper size of waterway openings, the Committee submits two additional formulas to supplement those appearing in previous volumes of the Proceedings; also additional conclusions based on further study are presented. . . . A valuable report is offered on methods of correcting soft spots in railway roadbed where it is impracticable to stabilize by drainage, the different methods being illustrated. . . . Study has been given to desirable width of roadbed in cuts and on fills and desirable slopes of banks under varying conditions of present-day loadings. . . . The Committee has also given study to methods of protecting against drifting snow and methods of removal of snow on the line and in yards and terminals, and has divided the subject into two sections—protection and removal. . . . During the past two years the Committee has been engaged in the formulation of specifications for pipe line crossings under railway tracks. In the current report the specifications are resubmitted and are offered for approval and insertion in the Manual. Since the promulgation of the report, a conference has been held with representatives of the American Petroleum Institute, at which a number of changes have been proposed.

Committee on Ballast (A. P. CROSLEY, *Chairman*).—The Committee has continued its study of specifications for prepared gravel ballast, including best method of testing for hardness, abrasion and resistance to weathering, and presents in tabular form the replies to questionnaire on the extent the Association's present specifications for prepared gravel ballast are being used and on the service record in the roadbed of specific gravels on which detailed laboratory tests have been carried out. . . . As a result of further study of specifications for stone ballast, including method of testing resistance to weathering, a modified abrasion test is submitted as information. . . . An interesting and valuable report on comparative costs of maintaining track on various kinds of ballast is presented. . . . In studying the subject of proper depth and kind of sub-ballast, the Committee finds it advisable to recommend certain revisions in the Manual, including a definition of sub-ballast, proper depth of ballast, and changes in captions of ballast sections.

Committee on Ties (W. J. BURTON, *Chairman*).—The Committee has continued its study of adherence to standard specifications for cross-ties, and reports additions to the mileage of roads covered by the American standard. . . . For many years, this Committee has reported on the use of substitute ties and in the current report statements are included of roads making tests of such substitute ties. Tables are presented giving complete data on tests of substitute ties in the United States. . . . Extremely valuable data is presented in the form of tables relating to tie renewal averages per mile maintained. The tables include density of traffic figures, useful for making comparisons of items of track maintenance other than ties, as well as when ties are subject of inquiry. . . . An interesting report is presented on method of proper com-

parison of renewal costs per mile maintained, with adjustment for variables, such as traffic density, rate of installation of treated ties, etc. . . . As the first step in a study of the subject of tie renewal practice, including method of inspection and renewal, check of such inspection and adherence to such inspection, a questionnaire has been issued to develop the data necessary to draw conclusions and to make recommendations. . . . On the economies of the use of 8-ft. 6-in. and 9-ft. ties as compared with 8-ft. ties, the Committee, to secure additional data, considers it necessary to establish one or more test sections, but in view of business conditions, it has been impracticable to install such test sections during the past year. . . . A valuable report is presented on the economical uses for old ties which must be removed from track and bridges.

Committee on Rail (Earl Stimson, *Chairman*).—Under the heading, "Revision of Manual," the Committee offers a number of important changes, including (a) reduction of the carbon content and adjustment of manganese content in the Rail Specifications; (b) change in silicon content; (c) classification markings; (d) branding and stamping; (e) revision of form for reporting rail failures in main track. . . . The Committee reports briefly on the present status of the joint investigation being carried on at the University of Illinois by the Rail Committee and the Rail Manufacturers' Technical Committee, to determine the cause and remedy for transverse fissures and other rail failures. . . . The report also includes rail failure statistics and transverse fissure statistics for 1931; also, operating results of the A.R.A. Rail Fissure Detector Car. . . . Specifications for Spring Washers are presented for the use of those who purchase such device. . . . Relative merits of rail sections heavier than 100-lb. per yard from the standpoint of economical distribution of metal and strength, are discussed, and in connection with this phase of the subject, the Committee recommends the withdrawal from the Manual of the 120-, 140- and 150-lb. R.E. Rail sections; and in lieu of the 130-lb. R.E. rail section, the Committee offers for approval and insertion in the Manual a new 131-lb. R.E. rail section. . . . An illuminating article is included entitled "The Design of a Rail Section," by Robt. Faries, a member of the Committee.

Committee on Track (C. R. Harding, *Chairman*).—A comprehensive and valuable report is presented on the subject of string lining of curves by the chord method, with tables suitable for the use of trackmen. . . . The Committee submits a revised plan for claw bar, including an alternate claw bar. . . . A plan showing the application of wing wheel risers to manganese steel frogs is offered for approval. . . . In connection with the subject of track construction in paved streets, the Committee presents a plan for approval entitled "Straight Double Tongue Switches for Engine Wheel Base not over 14 ft. 6 in. for Use in Paved Streets.". . . . A most valuable report is presented on the subject of gage of track and elevation of curves with reference to the use of roller bearings on railway equipment. . . . Another useful and practical report is offered on selective welding up at joints, instead of welding out of face. . . . Standard wheel flanges, treads and gages are discussed and a revised plan is offered for approval. . . . Damage from brine drippings from refrigerator cars is dealt with briefly.

Committee on Buildings (A. L. Sparks, *Chairman*).—In line with its assignment, "Preparation of Specifications for Railway Buildings," the Committee presents Section 29, Electrically Operated Freight or Baggage Elevators, for criticism and discussion. . . . A comprehensive report is presented on modern methods of heating small railway buildings, showing comparative advantages of warm air, hot water, steam and possibly fan-unit systems. . . . The Committee also submits a valuable report on the design and construction of modern fruit and produce terminal buildings. . . . (Reference is here made to the report on produce terminals of the Yards and Terminals Committee in 1932, Vol. 33, pp. 116–125). . . . An excellent report is made on the use of materials other than brick, stone and cement in exterior and interior walls, partitions, floors and ceilings of buildings.

Committee on Wooden Bridges and Trestles (COL. H. AUSTILL, *Chairman*).—A number of changes in the Manual are proposed. . . . Progress is reported on a number of subjects, including simplification of grading rules and classification of timber for railway uses; overhead wooden or combination wooden and steel highway bridges; design of standard wooden trestles for heavy loadings; relative merits of concrete and treated wooden trestles; bearing power of wooden piles, and method of determination; improved design of timber structures to give longer life with lower cost of maintenance, and design of washers, separators, cap stringer straps and other trestle fastenings. . . . The Committee presents a supplemental report on the subject of best relationships between the energy of hammer and weight or mass of pile for proper pile driving. . . . An interesting report is offered on improved methods of strengthening existing bridges.

Committee on Masonry (M. HIRSCHTHAL, *Chairman*).—In the current report of the Committee, a number of revisions of the Specifications for Portland Cement Concrete, Plain or Reinforced, are proposed and are recommended for approval. In connection with the subject, Specifications and Principles of Design of Plain and Reinforced Concrete, the Committee presents a design for a ballasted deck reinforced concrete trestle, with sections and details. Under this same heading there is presented an important monograph by Prof. Hardy Cross, a member of the Committee, entitled "Rigid Frame Bridges." Progress is reported on developments in the science and art of concrete manufacture, under the heading "Curing." An especially valuable report is presented under the heading "Specifications for Repairing Deteriorating Concrete," and which are submitted for insertion in the Manual. In connection with the subject, "Design of Expansion Joints Involving Masonry Structures," the Committee presents a series of sketches of expansion joints involving masonry structures to meet various conditions.

Committee on Grade Crossings (J. G. BRENNAN, *Chairman*).—The Committee has collaborated with the Signal Section in developing detail plans of "Number-of-Tracks" sign, both painted and reflector lenses; also, in the preparation of detail plans of the illumination of highway cross-buck signs by means of reflector lenses. . . . Signal Section specifications on reflector units and railroad highway grade crossing signs are presented and are recommended for endorsement. . . . A revision of the highway crossing sign, heretofore adopted, is submitted, by omitting the 50-degree angle shown between the blades. . . . A comprehensive table is presented, consisting of laws, regulations and practices governing dimensions and clearances affecting construction, protection, elimination and separation of grades of highway grade crossings, of the several states and of the provinces of Canada. . . . The laws and practices for determining division of costs of highway grade crossing separations are given in abstract form and in tabular form. . . . An interesting report on the use of concave street sections for grade separation subways and transition from crown to concave sections is presented. . . . As a result of its study of the subject of stock guards—types, uses and necessity, the Committee submits its findings, based on replies to a questionnaire, that in some sections of this country, due to changed conditions, stock guards are no longer required, while in other parts of the country they are still in use.

Committee on Signals and Interlocking (P. M. GAULT, *Chairman*).—The Committee reports progress on developments of automatic train control. . . . On the subject of increased efficiency secured in railway operation by signal indications in lieu of train orders and timetable superiorities, the Committee presents an interesting report on the economic results of the Missouri Pacific installation, including a statement of the total saving effected in 1930 over 1929. . . . A synopsis of the current activities of the Signal Section is included in the report. . . . An interesting report is made on the possibility of providing suitable protection at less cost than the present-day practice for both construction and maintenance of signals and interlocking. . . . The Committee presents a report on the use of flashing lights in railway signals,

and cites the practice of the Missouri Pacific, Pennsylvania, Southern Pacific, and Michigan Central Railroads.

Committee on Records and Accounts (C. C. HAIRE, *Chairman*).—The Committee presents a comprehensive bibliography on the general railway situation; on valuation; and on depreciation accounting. . . . A valuable report is presented on drawings and drafting room practices, including a revision of the graphic symbols now in the Manual. . . . Further study has been given during the year to the various forms either in the Proceedings or the Manual, to determine which forms are obsolete and of little use; which forms should be held in abeyance, and which should be retained, with or without revision, bearing in mind that a proposed new uniform system of accounts embodying depreciation accounting is under consideration, and it is therefore deemed best to hold these matters in abeyance for the present. . . . The Committee reports progress on methods used in recapture proceedings. . . . Progress is also reported on the subject of developments under I.C.C. Order No. 15100—Depreciation Charges of Steam Railway Companies. . . . Similarly, progress reports are made on methods for avoiding duplication of effort and for simplifying and coordinating work under the requirements of the I.C.C. and on practice to be followed in preparing data with respect to valuation, allocation of operating and maintenance costs to various zones and allocation of costs to specific services rendered.

Committee on Rules and Organization (E. H. BARNHART, *Chairman*).—A revision of the rules for the inspection of bridges, trestles and culverts is offered for approval. . . . Rules for the Maintenance of Bridges—Masonry, and Rules for the Maintenance of Terminal Structures other than Buildings are presented for approval and insertion in the Manual. . . . The Committee presents for discussion appropriate titles for Assistant Engineers, with the view of later offering definite recommendations for insertion in the Manual. . . . A series of rules for fire prevention as applying to the Maintenance of Way Department are presented as information at this time, with the expectation of later submitting such rules for final approval.

Committee on Water Service and Sanitation (R. C. BARDWELL, *Chairman*).—Tables showing detailed weights and dimensions for various classes of cast iron pipe and fittings, inadvertently omitted from the Manual, are submitted for inclusion therein. . . . The Committee has continued its study of methods and value of water treatment with respect to estimating and summarizing possible savings effected and contributes additional valuable data. . . . Methods for reporting annual summary water station and treating plant operation are interestingly discussed. . . . Continuing its study of developments of deep well pumping equipment, the Committee presents a valuable report. The subject is reviewed and mentions improvements in deep well equipment. A series of conclusions are submitted as information. . . . Standard methods for analyses of chemicals used in water treatment are offered for approval and insertion in the Manual. . . . Reference is made to the report of the Joint Committee on Railway Sanitation, issued by the American Railway Association, and comments are made thereon. . . . An interesting and valuable report is presented on sewage disposal where sanitary facilities are not available.

Committee on Yards and Terminals (H. L. RIPLEY, *Chairman*).—The Committee presents formulae for use in designing retarder hump yard gradients, running from the crest of the hump to the lower end of the classification yard; revisions of the section on test weight cars, relating to the rules for the location, maintenance. operation and testing of railway track scales are offered for approval. . . . Continuing its study of produce terminals, the Committee presents a series of recommendations, including general types of produce terminals, buildings, track layouts, driveways, platforms, icing, garbage and refuse disposal, and miscellaneous items. A condensed summary of interesting data obtained from a questionnaire is also included. . . . In connection with the

study of the report on hump yards, the Committee, in the current report presents two graphic methods for use in designing gradients in connection with the application of retarders to hump yard operation. The first method is an application to a typical classification yard of 45 tracks and is explained and its application demonstrated; the second method is an application to a typical classification yard of 50 tracks, and is also explained and its application demonstrated by means of diagrams. . . . For the past two years, the Committee has made a comprehensive study of the location and design of airports in coordination with railway facilities, and as a result presents an interesting and timely report. . . . In connection with the general subject of scales, the Committee submits as information, rules for the maintenance and transportation of track scale test weight cars, and a definition of a standard test of a railway track scale. . . . The practice of previous years in presenting a bibliography of railway stations, yards, marine terminals and airports has been continued, and a list of articles appearing in current periodicals is presented.

Committee on Iron and Steel Structures (A. R. WILSON, *Chairman*).—As a result of its study, the Committee offers a series of conclusions on the subject of track anchorage over bridges and similar structures. . . . Tentative specifications for fusion welding and gas cutting for steel structures are presented as information and discussion. . . . The Committee presents an interesting report on repainting of steel bridges, with special reference to the condition requiring repainting and economical method of doing the work. . . . In connection with the study of the subject of bronzes for various purposes in relation to iron and steel structures, the Committee presents a comprehensive monograph entitled "The coefficient of friction of bearing metals for bridge seats," by R. P. Davis, a member of the Committee, prepared in collaboration with G. P. Bromsliter, of the West Virginia University.

Committee on Wood Preservation (F. C. SHEPHERD, *Chairman*).—Owing to differences encountered when creosote is distilled at localities differing widely in altitude, the Committee, as a result of investigation, has prepared a table of temperatures at which fractions should be cut to correct distillation temperature for different altitudes. . . . The Committee also presents tables of volume correction for creosote, creosote coal-tar solution (up to 50 per cent tar) and coal tar, and specific gravity correction table for creosote, creosote coal-tar solution (up to 50 per cent tar) and coal tar. . . . Service test records for treated ties are given for the following roads: Great Northern, Baltimore & Ohio, Chicago, Burlington & Quincy, Rock Island, Union Pacific, and City of Minneapolis Filtration Plant Railway; there is also presented an interesting tabulation of cross-tie renewals per mile of all track maintained, 1911–1931, both inclusive. . . . Continuing its study of piling used for marine construction, the Committee reports on the present condition of the long-time test pieces installed at various places in this country as well as reports from foreign countries. The Committee is cooperating with the Chemical Warfare Service of the U.S. Army in this study. . . . The Committee presents the results of extensive tests made by the Santa Fe to determine the effect of incising and treatment on the strength of Douglas fir stringers and also the comparative strength of boxed heart and side-cut stringers; specifications for the treatment of air-seasoned Douglas fir are presented. . . . A most interesting report on destruction by termite and possible ways of prevention is offered as information.

Committee on Electricity (W. M. VANDERSLUIS, *Chairman*).—In lieu of a formal report, the Committee reprints for the information of the A.R.E.A. membership, the reports made to the Electrical Section in 1932. This compilation deals with the following subjects: Inductive coordination; power supply; electroysis; cooperation in miscellaneous regulations; overhead transmission line and catenary construction; economics of railway operation; standardization of insulating tape and of insulators; protection of oil sidings; specifications for track and third-rail bonds; illumination; design of indoor and out-

door substations; high tension cables; application of corrosion-resisting materials to railroad electrical construction; form of power contract for large blocks of power, and radio antennae on cars in electrified territory.

Committee on Uniform General Contract Forms (F. L. Nicholson, *Chairman*).—A form of agreement for pipe line crossings under railway tracks for the use of railway property by pipe lines generally paralleling the railway is submitted as a progress report and for discussion. . . . Progress is also reported on form of agreement for the purchase of electrical energy in large volume (such as required for traction purposes); on form of conveyance of title granting the right to construct and maintain air right buildings over railway property, and on form of agreement with public authorities for highway grade crossing illumination or separation.

Committee on Economics of Railway Operation (J. E. Teal, *Chairman*).—In continuation of its assignment of "methods for obtaining a more intensive use of existing railway facilities," the Committee presents an exhaustive study on forecast of improvement in train operation on a single track railroad equipped with short sections of double track with spring switches and centralized traffic controlled manual block. . . . Another valuable feature of the current year's report of this Committee is a study of the methods for determining the most economical train length, considering all factors entering into transportation costs. As a supplement to this report, a discussion on locomotive development is presented, including train resistance formulas.

Committee on Economics of Railway Labor (F. M. Thomson, *Chairman*).—The current report supplements the previous reports made by this Committee on the effects of recent developments in maintenance of way practices on gang organization, and supplements the information previously given for the C. M. & St. P., Pennsylvania, Great Northern, Boston & Maine, Missouri Pacific, C. B. & Q., Lackawanna, Erie and Lehigh Valley Railroads. . . . The Committee reviews briefly reports made in previous years on standard methods for performing maintenance of way work for the purpose of establishing units of measure of work performed. . . . A timely report is offered on the use of motor trucks in maintenance of way and structures work. A table is presented listing railways which have utilized such equipment in engineering and maintenance work. . . . During the past year, the Committee made a comprehensive study of gang organization and methods of performing the more common tasks of maintenance of way work, including a revision of the time studies now in the Manual to bring them in accord with modern mechanical methods. As a result of this review, the Committee presents a most interesting and illuminating report. . . . Progress is reported on a number of assigned subjects.

Committee on Shops and Locomotive Terminals (L. P. Kimball, *Chairman*).—An interesting illustrated report is presented on firing-up stations for locomotives, including location and types of installation. . . . The Committee presents a report on turntables, dealing with the functions of such devices, their place in the locomotive terminal design, and the essential general features of construction and maintenance. A series of conclusions are offered as a substitute for corresponding material in the Manual under the general headings of "Turntable" and "Turntable Pit". . . . A valuable report is presented on the application of unit heaters to shops and locomotive terminals, including a description of such installations, types of unit heaters, selection of heating system, size and selection of unit heaters, location of heaters in shop buildings, unit heaters for engine houses, automatic control, and quietness of operation.

Committee on Standardization (J. C. Irwin, *Chairman*).—The Committee calls attention to the value of the recommendations embodied in the Manual, and the importance of their use in the interest of uniformity in general practice. Stress is laid on the importance of keeping the Manual up to

date. . . . An outline of the organization and purposes of American Standards Association is given for the information of the membership. . . . A list of A.S.A. projects on which members of the Association are represented is presented. . . . The Committee also points out the importance of the use and citation of A.S.A. standards. . . . A study is being made as to subjects recommended for national standardization, such as specifications for creosote for wood preservation; specifications for trolley wire and messenger wire; wire and sheet metal gages; and grading rules and dimensions of lumber. . . . A study is also being made of A.R.A. recommended standards for railroad highway grade crossing protection with the view of standardization. . . . The report includes a statement of the Canadian Engineering Standards Association activities for 1932. . . . A list of standards approved by the American Standards Association for the period September 1, 1931, to September 1, 1932, is presented.

Committee on Maintenance of Way Work Equipment (C. R. Knowles, *Chairman*).—The Committee has continued its study of section duty motor car parts and accessories, and offers for inclusion in the Manual a series of specifications covering fuel line connections, sizes of cord belts, gasoline tanks, brake shoes and ignition systems. . . . A comprehensive report is presented on types of snow-melting devices as an aid in facilitating train operation and reduction in maintenance cost. Particular attention is called to this valuable report. . . . Another interesting report is offered on the use and adaptability of track type tractors in maintenance of way work. The report covers general description of the two types of tractors, auxiliary equipment, classes of work for which adapted, and examples of specific uses, including detail cost figures. . . . The organization for use and maintenance of tie tamping machines, both air and electric, is treated fully, together with diagrams of suggested pipe arrangement for four, eight and twelve tool pneumatic outfits. . . . The Committee presents a timely report on tie adzing, scoring and boring machines, with illustrations. . . . Still another valuable report is that dealing with the use of ditching spreaders in maintenance work.

Committee on Stresses in Railroad Track (Dr. A. N. Talbot, *Chairman*).—The Committee reports progress on the preparation of its Sixth Progress Report, which will be made available in one of the early summer Bulletins. . . . Reference is made to the accumulated test material of the tests made on the Pennsylvania Railroad; the Chesapeake & Ohio Railway; the Missouri Pacific Railroad, and laboratory experimental work on several forms of rail-joints.

Committee on Clearances (A. R. Wilson, *Chairman*).—In the current report, the Committee presents as information outline diagram of a proposed A.R.A. box car, and a clearance diagram for pantagraph.

Committee on Waterproofing of Railway Structures (J. A. Lahmer, *Chairman*).—The Committee presents, as information, specifications for membrane waterproofing, on which comments and criticisms are invited.

Secretary E. H. Fritch:—I move that the reports of the Secretary and Treasurer be approved.

The President:—Gentlemen, you have heard the reports. Is there any discussion? All in favor of approving the reports will say "aye"; contrary, "no". It is carried.

As Mr. Fritch has stated, in the past year we have lost a number of members, some very valuable members and several of them active members. I wish that you would all rise for a few seconds and pay tribute to their memories.

(The convention arose and stood in silent tribute to the memories of the deceased members.)

The President:—A number of prominent railway officials were invited to honor us with their presence here today, but unfortunately conditions prevented their attendance. Mr. R. H. Aishton, President of the American Railway Association, expected to be here, but has been obliged to send his regrets.

The first Committee to report is Committee XX—Uniform General Contract Forms. The report will be presented by Mr. F. L. Nicholson, Chief Engineer of the Norfolk Southern, Chairman.

(For Report, see pp. 125–129.)

The President:—The next report is that of the Committee on Wooden Bridges and Trestles. The report will be presented to you by Col. H. Austill, Bridge Engineer of the Mobile & Ohio, who is Chairman of the Committee.

(For Report, see pp. 65–74.)

The President:—The third report is that of the Committee on Iron and Steel Structures. This report will be presented to you by its Chairman, Mr. A. R. Wilson, Engineer Bridges and Buildings of the Pennsylvania.

(For Report, see pp. 285–308.)

Vice-President W. P. Wiltsee:—The report on Clearances will also be presented to you by Mr. A. R. Wilson, who is Chairman of the Committee.

(For Report, see pp. 261–262.)

Vice-President W. P. Wiltsee:—The next Committee to report is that on Electricity. The report of the Committee will be presented by its Chairman, Mr. W. M. Vandersluis, General Superintendent Telegraph and Signals, Illinois Central System.

(For Report, see Bulletin 348, August, 1932, pp. 3–126.)

Vice-President W. P. Wiltsee:—The next report is that of Committee X—Signals and Interlocking. The report will be presented by Mr. P. M. Gault, Signal Engineer, Missouri Pacific Lines, Chairman of the Committee.

(For Report, see pp. 263–272.)

AFTERNOON SESSION

The President:—The first report on this afternoon's program is that of the Committee on Yards and Terminals. In the absence of the Chairman, Mr. M. J. J. Harrison, Vice-Chairman of the Committee, General Scale Inspector of the Pennsylvania, will present the report.

(For Report, see pp. 167–207.)

The President:—The entire world is looking with interest to the Century of Progress Exposition which will be presented in Chicago during the five months of this summer, beginning June 1. This Exposition, which will depict the progress in every respect of human endeavor during the last century, is devoting special attention to transportation. The first major building completed was the Travel and Transport Building. In and adjacent to this building there will be presented an exhibit of transportation by rail that will be of interest to every railway man.

Mr. H. C. Wanner, Chief of the Divis'on of Applied Science and Industry for the Century of Progress, is with us and will present a brief description of that portion of the Century of Progress exhibition that will be of special interest to those concerned with transportation. Mr. Wanner.

Mr. H. C. Wanner (Century of Progress):—Mr. President and Gentlemen: One of the most interesting parts of the Century of Progress is the area devoted to the travel and transport story. About 75 acres of land is devoted to this part of the picture. As your President has told you, the first large building completed was the Travel and Transport Building. We are very happy to say to you that we feel that the most representative showing in our entire Fair is the one which will be shown by the railroad industry. All of the major lines are a part of our show.

Generally speaking, the travel and transport area is divided into three major divisions. Along the lake front we are going to have, three times a day, the story of transportation from the early days up to the present. We will have a number of actors and actresses in costume. In other words, it will be something along the line of the "Iron Horse," which was so successful in Baltimore when the Baltimore & Ohio put it on. Of course, th's will not be limited strictly to rail transportation but rail transportation will have an important part in it.

South of the Travel and Transport Building is an outdoor area devoted to railway transportation, with five tracks out there. Track 5 is an exhibit by the Great Northern, the Northern Pacific and the Burlington, jointly, of their finest equipment, a complete line—locomotives and all. Track 4 is for the "Royal Scot," a complete train being brought over here, landing in Montreal. It is going to make a trip through the eastern part of the United States. It will be in St. Louis on Memorial Day and will be here on the thirty-first of May and all during the Exposition. Track 3 will be for the Baltimore & Ohio, a complete train track. Track 2 will be for a section of the Mexican presidential train, quite an interesting showing. The Mexican government further has offered to send up the very famous collection of jewels and have it on this train. For Track 1 the Delaware & Hudson is sending one of their very large locomotives. I understand that the locomotive is so large that they had some difficulty in finding out how to get it here, on account of clearances. There will also be other exhibits on Track 1. So far the General Steel Castings Company has contracted to send up one of their new hopper coal cars. The Mine Rescue car will be on this track, exhibited by the United States Government. There will probably be several other exhibits in this outdoor show.

The building itself is divided into the great dome, about which you possibly have heard. It contains the famous echo. Everyone who comes to the World Fair now hears this echo and is considerably amused by it. This echo will not be present during the time of the Fair, of course.

This dome is supported from the top. The roof does not rest on the sidewalls. It is entirely supported on the principle of the suspension bridge. In this dome will be located, first, historical transportation mediums, old automobiles, old locomotives, old motor trucks, things of that kind, with the very latest examples of the same type of transportation. The Pullman Company is going to have two aluminum Pullman cars, the very latest thing, among other exhibits.

In the building itself is where the major railway show will be held, that is, the showing on the part of the railroads themselves. Starting at the north end of the railway show, we have the Pennsylvania and Rock Island exhibit, the Baltimore & Ohio, New York Central, Illinois Central, Pullman Company, General American Tank Car, Chicago, Milwaukee, St. Paul & Pacific, Chicago & Northwestern, Railway Express Agency, Delaware & Hudson, and the Chicago, Burlington & Quincy. All of these rail-

roads are going to show an extremely interesting picture. A great deal of it, of course, is going to deal with travel, to interest people in seeing parts of the country they have not seen.

Our Fair is going to open on time. There is not any question of that. (Applause).

The President:—Mr. Wanner, on behalf of this Association I want to thank you for the time you have taken in giving us a very complete description of the Exposition. Thank you very much.

The President:—The next report is that of the Committee on Shops and Locomotive Terminals. This will be presented to you by the Chairman, Mr. L. P. Kimball, Engineer of Buildings, Baltimore & Ohio.

(For Report, see pp. 251–260.)

Vice-President John E. Armstrong:—The report of the Committee on Records and Accounts will be submitted to you by its Chairman, Mr. C. C. Haire, Engineer of Capital Expenditures, Illinois Central System.

(For Report, see pp. 209–250.)

Vice-President John E. Armstrong:—The next report is that of the Special Committee on Waterproofing of Railway Structures. This will be presented to you by its Chairman, Mr. J. A. Lahmer, Senior Assistant Engineer of the Missouri Pacific.

(For Report, see pp. 273–283.)

Vice-President John E. Armstrong:—The next report to be presented to you is that of the Committee on Standardization. This report will be handled by Mr. J. C. Irwin, Valuation Engineer of the Boston & Albany, who is Chairman.

(For Report, see pp. 309–321.)

Vice-President John E. Armstrong:—The next report is that of Committee XXVII—Maintenance of Way Work Equipment. Mr. C. R. Knowles, Superintendent Water Service, Illinois Central System, Chairman of the Committee, will present the report.

(For Report, see pp. 355–420.)

EVENING SESSION

The President:—The first report this evening will be that of the Special Committee on Stresses in Railroad Track. This report will be presented to you by Dr. A. N. Talbot, Professor Emeritus of the University of Illinois, Chairman. Dr. Talbot's report will be accompanied with lantern slides.

(For Report, see p. 703.)

The President:—Next we will have the report of the Rail Committee. Mr. Earl Stimson, Chairman of the Committee, Chief Engineer Maintenance, Baltimore & Ohio, will present the report.

(For Report, see pp. 605–645.)

WEDNESDAY, MARCH 15, 1933

MORNING SESSION

The President:—The report of the Committee on Roadway will be presented to you by its Chairman, Mr. C. W. Baldridge, Assistant Engineer of the Santa Fe.

(For Report, see pp. 131–165.)

The President:—The report of the Committee on Ballast is next in order. The report will be presented to you by its Chairman, Mr. A. P. Crosley, Division Engineer of the Reading Company.

(For Report, see pp. 521–531.)

The President:—Mr. C. J. Geyer, Assistant to Vice-President, Chesapeake & Ohio Railway, Vice-Chairman of the Committee on Track, will present the report in the absence of the Chairman.

(For Report, see pp. 491–520.)

The President:—We have with us today two men who were sent here as delegates or representatives of the National Railways of Mexico and of that Government. Unfortunately, I cannot speak their language and I cannot remember their names. We have a man who has been down in Mexico among the cypress trees quite recently, and I am going to ask Dr. von Schrenk if he will kindly introduce these gentlemen and ask them to rise so that we can know them.

Dr. Hermann von Schrenk (St. Louis):—Mr. President, I take pleasure in introducing Senor Francisco Malagamba and Senor Jose G. Jauregui, of the Mexican National Railways (Applause). I might add to this, Mr. President, that I was requested by Senor Madrazo Arcocha, Chief Engineer of the Mexican National Railways, to present his greetings to the convention and express his regret that he was unable to be here with you.

The President:—Thank you very much. We are glad to see these gentlemen here and we hope they take our message of greeting back to their country.

Senor Francisco Malagamba (Mexican National):—Mr. President and Gentlemen: The Chief Engineer of the National Railways of Mexico gave us his representation to this honorable Association. We are very interested in all your reports. We appreciate very much the very useful knowledge and new knowledge here exposed. My knowledge of the English language is not enough as I would wish to expose my thoughts, but anyway, I beg your pardon and give to you many thanks for your kindness (Applause).

The President:—Thank you very much. That came from the heart, as he wrote that himself. He did not have Dr. von Schrenk help him with it.

AFTERNOON SESSION

The President:—The first report on this afternoon's program is that of the Committee on Ties. The report will be presented to you by the Chairman, Mr. W. J. Burton, Assistant to Chief Engineer, Missouri Pacific Railroad.

(For Report, see pp. 323–353.)

The President:—The next report is that of the Committee on Wood Preservation. Mr. F. C. Shepherd, Consulting Engineer of the Boston & Maine Railroad, is Chairman.

(For Report, see pp. 421–489.)

The President:—Next we have the report of the Committee on Rules and Organization. Mr. E. H. Barnhart, Assistant Division Engineer, Baltimore & Ohio Railroad, is Chairman.

(For Report, see pp. 75–79.)

The President:—Next will be the report of the Committee on Economics of Railway Operation. The report will be presented by the Chairman, Mr. J. E. Teal, Special Engineer—Operation of the Chesapeake & Ohio Railway.

(For Report, see pp. 533–575.)

The President:—We have a gentleman with us here today whom we are all glad to see. Mr. C. A. Wilson, Consulting Engineer, of Cincinnati, Ohio, is a Charter Member of the Association. He is No. 9 and second on the present roll of members. He has not missed a single convention since the organization of the Association in 1899. He was also present at the preliminary meeting at which the proposal to organize the Association was discussed. I should like to have Mr. Wilson stand up. He has been in railroad work for over fifty years (Applause).

Mr. C. A. Wilson: Mr. President, I should like to say a few words, but I have such a cold that I shall have to reserve them for some other time. Thank you all (Applause).

Vice-President W. P. Wiltsee:—The report of the Committee on Economics of Railway Labor will be presented by the Vice-Chairman, Mr. Lem Adams, Chief Engineer, Union Pacific Railroad.

(For Report, see pp. 101–124.)

Vice-President W. P. Wiltsee:—We will now have the report of the Committee on Water Service and Sanitation. Mr. R. C. Bardwell, Superintendent Water Supply, Chesapeake & Ohio Railway, Chairman of the Committee, will present the report to you.

(For Report, see pp. 81–100.)

Vice-President W. P. Wiltsee:—Next is the report of the Committee on Buildings. The Chairman, Mr. A. L. Sparks, Architect, Missouri-Kansas-Texas Lines, will present the report.

(For Report, see pp. 681–702.)

The President:—The next Committee to report is that of the Committee on Masonry. Mr. Meyer Hirschthal, Chairman, Concrete Engineer of the Lackawanna, will make the presentation.

(For Report, see pp. 577–604.)

The President:—We will now have the last report, that of the Committee on Grade Crossings. The Chairman, Mr. J. G. Brennan, Engineer of Grade Crossings, New York Central Railroad, will present the report.

(For Report, see pp. 647–679.)

The President:—This completes the consideration of Committee reports, and the next order of business is New Business. Has anyone anything to offer under that heading?

Mr. Robert H. Ford (Rock Island):—I move, sir, the adoption of the following resolution:

"WHEREAS, The officers and members of the American Railway Engineering Association realize fully the sacrifice which must be made at this time by Presidents of large railway systems in order to attend meetings far removed from their headquarters; therefore, be it

"*Resolved,* By the American Railway Engineering Association, in convention assembled, that the thanks of our Association be extended to President F. E. Williamson, of the New York Central Lines, for honoring us with his presence at our meeting, and that our gratitude be offered for the courageous and inspiring address delivered by him at our luncheon meeting on March 15th."

(The motion was regularly seconded, put to vote and carried unanimously.)

The President:—Is there any other new business?

Mr. E. M. Hastings (Richmond, Fredericksburg & Potomac):—Mr. President and Gentlemen: There are some things that all of us like to do. This is one of the things that all of us find much enjoyment in doing.

Mr. President, we have watched your progress in this Association for a great many years. I say "we," because I personally have for many years. Those of the membership who are younger have been watching with interest, certainly in the last few years. The honors that the Association have bestowed upon you have been well-deserved. In fact, it is the opinion of your humble servant that the Association has honored itself in the office to which it has elected you, and certainly you have honored the Association in the fulfillment of that office.

This past year particularly has been a trying one for all of us. It has been a trying one for you, but you have, with splendid spirit, with unselfish interest, with a devotion to service for the Association, so conducted its affairs that at this convention, when we all expected the attendance to be small, we have reached a goal almost as high as last

year. I think that is a great tribute to your untiring devotion for the Association and a tribute to you personally.

Therefore, it gives me very great pleasure and it gives me particular pleasure to present to you, on behalf of the Association, as a token of its esteem and its love for you, this plaque. You will note that the shape of it is the New York Central emblem, the oval. You will find thereon this inscription:

"In appreciation of valuable service rendered to the American Railway Engineering Association by John V. Neubert, President, 1932–1933.

"This tribute is dedicated to an outstanding Railway Engineer and able administrator, who has successfully piloted the Association and maintained its high standards of accomplishment in a difficult period."

I am honored, sir, in being privileged to present it to you.

(The convention arose and applauded.)

The President:—Mr. Hastings and Members of the American Railway Engineering Association: I am a little touched now and it is pretty difficult to get me touched, but I am not going to cry because it is not the time. I am so greatly pleased that I do not know how to express it. The only way that I can possibly do so is by mentioning an incident that happened in this town a number of years ago when the late Senator Depew was a candidate for nomination for President against Garfield. He finally withdrew. As Senator Depew was on his way East he thought he would stop at the home of Garfield

to pay his respects. When they met, Senator Depew said, "I want to tell you that I am going back and I am going to work for you."

"Well," was the reply, "that is very nice, but I was not surprised that you withdrew and they chose me."

"Why?"

"What the country needs is a man who has constructive ideas, a man who is forceful in regard to conditions. You, for example, are a humorist, an after-dinner speaker. You are able in that capacity."

"Well, Mr. Garfield, they tell me, and I do know, that Abe Lincoln, who was President of this country, was more or less a humorist."

"But Abe Lincoln told those funny stories only to carry over his point."

"Well, when I die I hope the people will remember me for that instead of saying I was a great man."

What I am trying to bring out by that is that I tried to render, as your President, the best that I knew how. I tried to please.

In conclusion, as Mr. Hastings has said, we have been through some trying conditions in the past year. In fact, a great many of my friends have told me in the past few months, "We are sorry you get the tough break to be President of the A.R.E.A. without having the exhibit. Everything broke against you and the convention and meeting will not be as usual."

Furthermore, that same thing came back at me at other times—I am certain of this: If I had to go through it again, if it were possible that I would be chosen, knowing what I do now, I would say, "Let me take office when you have a year like this."

It was not me who did it. It was due to the inspiration that I got from my associates.

I wish to thank those men for what little or great I have done. I know I have made mistakes, but I want to give thanks and credit to the members as a whole, to the Board of Direction, and, last but not least, to my friend, Mr. Fritch (Applause).

On this occasion I want to thank also the Committee on Arrangements, of which Mr. Howson was Chairman, for the fine cooperation and the fine work they have done under the circumstances. I suppose my years are about ended, but I am going to take this, not for its intrinsic value, but in the spirit in which it is given, and I shall cherish it for the rest of my days. Thank you (Applause).

It is customary for the President to present a medallion to the outgoing member of the Board, which is fitting and appropriate. I am sorry for your sake as well as my sake that he is not present, because he is one of the finest characters who ever lived. He has not only done great work for the Association but for the community at large around Chicago—our good friend, D. J. Brumley (Applause).

On this medallion is inscribed: "To D. J. Brumley for outstanding contributions to the science of railway engineering."

On account of his health he is in Arizona and I am going to delegate Mr. Fritch to see that Mr. Brumley receives his medallion (Applause).

If there is no further business, the Secretary will announce the result of the election of officers.

REPORT OF THE TELLERS

We, the Committee of Tellers, report the following as the result of the count of the ballots:

For President:

W. P. Wiltsee	975 votes

For Vice-President:

Robert H. Ford	946 votes
C. R. Harding	4 votes
G. W. Harris	2 votes
G. S. Fanning	2 votes
W. H. Kirkbride	2 votes
E. M. Hastings	1 vote
Robert Faries	1 vote
Hadley Baldwin	1 vote
C. R. Knowles	1 vote
John E. Armstrong	1 vote
F. G. Jonah	1 vote
Bernard Blum	1 vote

For Secretary:

E. H. Fritch	972 votes

For Treasurer:

A. F. Blaess	967 votes

For Directors (three to be elected):

Lem Adams	521 votes
G. S. Fanning	501 votes
W. F. Cummings	381 votes
H. von Schrenk	375 votes
F. G. Jonah	347 votes
W. H. Penfield	240 votes
E. H. Barnhart	228 votes
E. G. Hewson	201 votes
E. I. Rogers	133 votes
A. R. Wilson	2 votes
A. A. Miller	1 vote
R. C. Falconer	1 vote
L. T. Nuckols	1 vote

For Nominating Committee (five to be elected):

H. R. Clarke	700 votes
J. R. Watt	601 votes
E. W. Caruthers	548 votes
E. R. Lewis	507 votes
F. L. Nicholson	457 votes
C. H. Mottier	427 votes
C. B. Stanton	397 votes
H. Austill	388 votes
J. H. Hande	372 votes
R. L. Cochrane	350 votes
W. C. Barnes	1 vote

The President:—Will Mr. Yager, Past-President, and Mr. Roberts please escort the President-Elect to the platform?

(President-Elect Wiltsee was escorted to the platform by Past-President Yager and Director Roberts.)

The President:—You know, this is quite a coincidence, as Mr. Wiltsee and I have been associated in one or another capacity since we have known one another. I hate to

give up this office, but they are kicking me out. It is a great pleasure for me to turn this office over to you. It is the highest office within the gift of this Association. Mr. Wiltsee, you are to be congratulated, and the Association is to be congratulated on its choice. I have the greatest confidence in regard to the success you will have. It cannot be otherwise because of the spirit shown here at this Association meeting.

About an hour before I was put in the Chair one of the Past-Presidents said to me: "John, you are going to get yours. I can feel it coming. Nobody knows the condition this business is going to be in two months from now. You are going to have no easy time."

I told him just about what I told you a little while ago. "If those times come, if they are rough, I hope to live to finish the year."

Mr. Wiltsee, I hope that conditions will improve. I hope the road gets smoother. But whether it gets smoother or rougher, let us hold our heads up and fight the thing through.

You do not know what this is do you? (Indicating gavel). This does not come from Ohio, where you were born. The head is made of walnut and the handle is made of hickory from the good State of Virginia. The wood was taken from the right-of-way of a railroad called the Norfolk & Western. Both of these woods are used for furniture and interior finish in those old Southern homes. They have been used in those palatial homes for years and years.

This is presented to you on behalf of your boys, who wish you all success. I now turn it over to you as President of this Association, wishing you all the success in the world. God bless you! (Applause).

President W. P. Wiltsee:—Mr. Neubert and Members of the Association: I thank you very much for electing me to the high office of President of your Association. It is an honor which I consider the highest that can be bestowed upon an Engineer in railroad service. I doubly appreciate my engineering education, as my engineering education has been obtained from the school of experience and the work in this Association.

We approach a new year, one in which no doubt we will have many problems, but we approach that without fear. I say that because in my contact with the officers and members of this Association, in my association as Director and Committee Chairman, which has covered a period of practically twenty-five years, I am familiar with the help that the President receives from the officers, Committee Chairmen and the membership at large. So I say we approach the coming year without fear of failure. I thank you all, gentlemen (Applause).

If there is no further business, the annual meeting is declared adjourned *sine die.*

E. H. Fritch

Secretary.

ADDRESS OF F. E. WILLIAMSON, Esq.

President, New York Central Lines

This organization impresses me in a very definite way. Whatever your training and pre-occupation, it is my belief that the membership of the American Railway Engineering Association comprises men of wide practical experience and broad judgment. The scope of the organization is well demonstrated by its Year Book, which discusses the work of some twenty committees. It seems to embrace the whole field of fixed railway plant. One is bound to be greatly impressed by the progress made in these matters. The wide range of adaptation in the work of caring for the property shows an alert progress. The progress made in cooperation with commercial producers in reducing the diversity of standards is noteworthy. This must tend for improved sources of supply; it must make for savings that are not confined to the railway market.

I am glad to talk with you about your relation to the railway work as one who appreciates your work—quite convinced that you know more about it than I do. I am willing to yield to no one in my belief in the importance of this work and of the thoughtful and efficient help that has been and will continue to be applied to our problems.

It is apparent to many that, for the time being at least, the horizon discloses no great construction projects for the railways. This kind of work has been largely done by your membership and its predecessors. It is most impressive. It has established a standard of physical plant that invites respect and admiration. It has brought our railways to an equipment and capacity for business that is unrivalled. A large part of this plant was, of course, built in pre-war days, when the costs were low. It is our good fortune that the enduring and serviceable character of such work, combined with the relatively low cost, is perhaps a major factor of safety in the present position of the railways. For the immediate present we have, it is true, a surplus of plant and capacity. Our construction needs are few. We have therefore an opportunity to concentrate upon maintenance problems. I cannot but feel that the research disclosed by you in methods and appliances is fortunately available at such a time. It is no doubt a great advantage that the continued study and adaptation of methods should be zealously pursued, not only as you have been doing, but with renewed zeal and belief in the service which such methods yield.

The railways are under competitive pressure, not acutely felt until this depression, but which has probably been quietly generating itself for the last fifteen years. Prior to that time the railways, as a whole, had a seller's market. The railway future seemed to follow the slope of steady growth in business that had prevailed for many years. Transportation was pretty much performed by the railways of the country. This is no longer true. We have splendid railways, built for heavy loads, locomotives that can haul a mile of cars, and we have half a mile of business. There are potential competitors, other than railways, for a great deal of the business that we had. They have some advantages which we do not share. These may become justly equalized in respect of regulation, taxation and equality before the law. Even then it is quite obvious that there is need to shape the railway plant and service to better advantage in this competitive field.

The rapid decline in business in the past three years has brought out the contrast between important main routes, on the one hand, and lateral and branch lines on the other. It seems as though the lateral and branch lines have shown the effects of the

Address delivered at the "Association Luncheon," Wednesday, March 15, 1933.

changes in the transportation business more sharply than the main lines. We find our main lines today still performing the general range of service that has been customary. It is true it has diminished in volume, but there seems no good reason for believing that to be a permanent change. The decrease is more a function of the general state of business of the country. The future volume of business for a considerable quantity of lateral and branch lines is, however, not so clear. The local business which once largely contributed to their earning power has been the subject of serious inroads from motor competition, operating on improved highways. While the equilibrium resulting from a rationalizing of railway and motor transport has probably not been disclosed we have no definite measure of the extent to which such disclosure, or even the resumption of general business, might help these lateral and branch lines. In many cases it is an involved question requiring close study and perhaps further experience. The first point seems to be to determine with more or less accuracy the character of service that can be expected to survive on such lines and to conform the physical standard of maintenance accordingly. In other words, it seems essential that the railway mileage that is eligible for an unrestricted variety of traffic ought to be confined to such parts of the mileage as are obviously now performing such character of service and likely so to continue. In this way your problem may be classified to advantage, both in the conduct of the work and its cost.

The investment of capital in a railway is mostly in road and equipment. Your particular interest is in that part of it which is invested in road. You are in a sense the custodians of the physical property represented by that investment. There is not only the responsibility for the care of the physical property to be borne but also of the physical and financial risk involved in its use. While the latter may not fall directly to your lot, you can be very helpful to those who must bear the ultimate responsibility, not only in your routine duties, but by your thought and co-operation among yourselves and with your railway associates of other professions. There is no body of men of the education, experience and judgment such as you possess but that is also possessed of potent social influences, which by their soundness and understanding may reach far and operate definitely upon the thought and action of the community and country.

It is not my purpose to talk with you about the physical aspects of this property with which you are so familiar and which you understand, no doubt, a great deal better than I do. I want you to look with me at this road investment as a physical instrument and a financial risk. A railway is chartered essentially to convey persons and property. This is the great beneficent power given it in the public behalf. It is in such a province that the greatest service may be rendered to the public. Railway transportation cannot be effective without motive power. That is inconceivable. We know as yet no way whereby it can be effective without cars and road. The investment in these physical factors is so interrelated that each reacts upon the other most intimately. An important change in one affects the other. These changes and the effects are functions of speed, weight and character of service, whether local to the line or general. The effect of the character of service upon the physical standard is worthy of deep study. So is the effect of the standards of motive power, equipment and road, each upon the other. I do not mean that these have not been studied and may not be well known. What I do mean is that there is a great margin of study that may be given to these relationships, under the new conditions disclosed to us by the present: first, to produce a more definite consciousness in our minds as to these relations, and, second, to pursue the objective that shall conserve the value (or investment) in what we have to more productive ends. Our consciousness of these essentials need not merely be de-

partmental, so to speak, but if it exists will be helpful in all ways in which our duties make us a part of the railway organization and the body of citizens.

There are many striking instances where road investment in railways has been conserved both in physical standard and service of capital. This points to an ideal, perhaps, but one that is highly useful. Thus obsolescence, as it is called, may be met with its own weapons. New and enlarged service and better results have been yielded with a minimum increase in fixed investment. Objectives may have been truly forecast or the interrelated factors may have been subject to more definite control in their reactions upon the plant investment. It may be that peak loads, either of business cycles or of seasonal variations, have been met by effort rather than by investment. Effort, of course, has the duration of the peak load. When met by investment that burden has a continuing duration, supported only by peak load. Generally speaking, investment in plant so founded can be adequately satisfied only by adequate business volume.

It seems patently desirable to work towards an end in which the yield per invested dollar shall increase. The alternative is to reach a point where that investment not only fails to sustain itself, but has a diminishing service value. Let us assume that the outlook of today requires increased service adaptation; that it invites careful classification of service in order to foster the available business. We lack means, but we must achieve service progress. We sense that passengers want to move over a satisfactory route. They want to be carried in cars better suited than ever to their comfort and safety. They want to spend less time between points of travel. Can these objectives be served only by increased plant investment? Where will the money come from? Can they be served with existing standards of road? Will the reduced time be accomplished by higher maximum velocities or by removing causes of subnormal operation? What part can effort and classification rather than additional investment play in the rational answers to these questions? With the decrease in the movement of fuel, ore, steel and other heavy commodities, the residual freight traffic seems to be of a character that requires a more critical service; more adaption of cars to shippers' needs; special equipment to protect individual production. Studies are current to disclose new ratios of dead weight to paying load by the use of lighter metals and efficient design. Freight is moving, in response to demand, at higher speeds aimed to reduce time enroute. The owners of goods in transit have learned to figure on the investment cost of the time in transit as a part of the cost to them of transportation. They will continue to do so. Above all other considerations in the public mind with reference to their patronage of the railways is no doubt the relation of transportation charges to the general price level. It seems probable that charges acceptable to them, that invite their patronage, can never quite escape the shadow of the price level. Do not such considerations suggest an operating and maintenance cost that must needs be less per unit of traffic than we now experience? What if the return of volume does not snap back to that which we have had heretofore, but is slowly won by our own effort and adaptation to these broad considerations, which in the end will determine the patronage and support of the railways.

I realize that no such financial achievement can precede a physical achievement. Moreover, no physical achievement of a new art is likely to transpire until taken hold of by men, alert and capable, who can project the physical procedure along lines in which financial salvation may lie. I do not believe in miracles in the sense of any radical change of standards or methods. I do believe that an objective may be as substantial in its reform as the best judgment of men may make it. Such an objective

establishes the trend and may be approached without dislocation of order or essentials. I would like to leave with you, therefore, these suggestions:

(1) We must shape our transportation product to our market;

(2) We must shape our plant investment and the care of it to our means;

(3) We must shape our physical standards to a conformity with such objectives.

It has been my good fortune to have an extensive acquaintance with railway men in various activities. I have spent my life in association with them. I am confident that the result of reflection and research upon this subject-matter by you, individually and collectively, will eventually be of great service to the country. There is no doubt of the recognition which you have from your fellow-countrymen. It is well deserved.

I thank you cordially and acknowledge my appreciation of the honor you have shown me today. (Applause.)

Everett Addison Hadley

A MEMOIR

EVERETT ADDISON HADLEY

Everett Addison Hadley

A MEMOIR

Everett Addison Hadley, Chief Engineer of the Missouri Pacific Railroad and Director of the American Railway Engineering Association, died at St. Louis, Mo., on November 11th, 1932, after several months illness. The funeral was held November 12th, at the Pilgrim Congregational Church of St. Louis. Funeral services were also conducted at Lowell, Mass., November 14th, by the pastor of the Highland Congregational Church. The interment was at Edson Cemetery in that city.

Mr. Hadley was born in Lowell, Mass., November 19th, 1879. He received his early education in that city, and in 1897 he became associated with the firm of Smith and Brooks, Civil Engineers and Surveyors, as a student apprentice.

In 1900 Mr. Hadley entered railway service with the Boston and Maine Railroad as draftsman, later serving as Assistant Engineer and Resident Engineer. His most important work while with the Boston and Maine Railroad was in connection with a large number of grade crossing elimination projects, of which he had charge of both design and construction. Many of the structures built under these projects are monuments to his artistic skill and ingenuity of design, one of the most beautiful being the stone arch underpass at Belmont, Mass.

In 1910 he came to St. Louis to accept the position of Engineer of Design with the Missouri Pacific Railroad and was later advanced to the position of Principal Assistant Engineer. His outstanding ability was soon recognized as in 1915 he was promoted to Chief Engineer.

Under Mr. Hadley's direction as Chief Engineer more than one hundred and fifty million dollars were spent in modernizing the Missouri Pacific Lines. This vast sum was used on thousands of separate projects, including such monuments of engineering achievement as the second track work and grade reductions on the Eastern and Central Kansas Divisions, the grain elevators at St. Louis, Kansas City and Omaha, the Arkansas River Bridge at Little Rock, the passenger stations at Little Rock and Texarkana, and the St. Louis office building.

These larger projects by no means tell the full story of the improvements he directed, which now enable the Missouri Pacific to handle double the tonnage at double the speed, but with only one-fourth additional train miles. A large amount of detail supervision and planning were required for the great number of lesser grade and line changes, improvements in drainage, reconstruction of roadbed, relaying tracks with heavier rail, strengthening of bridges, reconstruction and enlargement of yards and other terminal facilities, all of which were essential to the handling of the heavier power and longer trains. Connected with this work was the determination and adoption of standards, to which feature Mr. Hadley gave much personal attention.

In handling this vast improvement program Mr. Hadley proved himself to be an executive as well as an Engineer. The work was done without friction and he was able to co-ordinate the work of the various departments of the railroad involved so as to effect harmonious action.

Although the demands of his position as Chief Engineer of a large railroad system were heavy and exacting, he freely assumed added work and sacrificed of his all too little leisure to contribute to the advancement of the art of railroading and of the engineering profession. This led to his becoming identified with many correlated activities.

Prepared by Earl Stimson, Chairman; W. J. Burton, W. D. Faucette, J. C. Irwin, A. F. Blaess, W. P. Wiltsee, R. C. Bardwell, R. C. White, Special Committee.

His interest in signal work was great and although he did not profess to be a Signal Engineer, he was able to bring to this work his ability to keep the ultimate objective in sight and to harmonize conflicting ideas so as to secure progress. This capacity was recognized when he was appointed Chairman of the Automatic Train Control Committee of the American Railway Association, a place which only a Signal Engineer might be expected to fill. He first became a member of this Committee on October 24th, 1925, and as Chairman of the Sub-Committee on Standardization he directed studies relating to problems of interchangeability of automatic train control devices, and practical methods were adopted for joint service between any of the train control devices then in use in the United States. Plans were made for actual road operating tests to demonstrate that the methods proposed are practicable, and it is the intention to continue this work that originated under Mr. Hadley's direction. He was elected Chairman of this Committee October 10th, 1931, and continued in that capacity until his death.

The location of the Missouri Pacific Lines in Arkansas and Louisiana brought Mr. Hadley into intimate contact with the great flood of the Mississippi River in 1927. He spent many weeks at the "front" in that campaign, where, in many counties, Missouri Pacific box cars were the only shelter for a large part of the population. During this flood he escorted President Hoover, then Secretary of Commerce, on several trips through the flood region. He became a member of the Mississippi Valley Flood Control Committee, consisting of the Chief Engineers of all the railroads operating in the territory affected. In connection with the work of this Committee, Mr. Hadley made frequent appearances before the House Flood Control Committee of the United States Congress. He took an active part in handling these flood control matters and made a most valuable contribution to the public service.

During Federal Control Mr. Hadley was Engineering Assistant to the Regional Director of the Southwestern Region. This brought him into contact with most of the railroad men of the Southwest. It was during this period that he was able to perform an outstanding service to the railroad engineering profession. This service is summed up in the following words of a recent letter:

> "We can all recall the time when the engineering profession of this country, particularly that section of it associated with and working for the railroads, had to a certain extent lost caste. Mr. Hadley went into this matter vigorously and most sensibly, recognizing the responsibility and duties of the various positions connected with railroad engineering departments and worked out a comprehensive plan recognizing the value of the Engineer, and largely through his efforts, not only in the Southwest, but in the whole country, the railroad Engineer was put on a just and fair basis as to duty, salary, etc., and this idea, promulgated by and fought for by Mr. Hadley, has been of great benefit to the engineering profession and their families. From his efforts he has done more to add to the happiness and peace of mind of the railroad Engineers . . . than any other Engineer I have ever known."

Mr. Hadley became a member of the American Railway Engineering Association in January, 1911. Almost at once he entered into the activities of the Association, becoming a member of the Committee on Wooden Bridges and Trestles in 1912 and serving on that Committee until 1920. He served on the Track Committee from 1921 to 1924 inclusive. At the time of his death he was a member of the Rail Committee, having been appointed in 1925, and Chairman of the Committee on Rivers and Harbors, having been appointed in 1931, after serving as Vice-Chairman in 1929 and 1930. He was Vice-Chairman of the Committee on Arrangements in 1930 and served as Chairman for the 1932 convention. In 1931 he was elected a member of the Board of Direction for the three-year term. In 1931 he was appointed a member of the Committee on Standardization. What a splendid record of service graciously given for the benefit of others.

That his interests were not wholly confined to railroading is evidenced by his membership in other organizations, including the American Society of Civil Engineers, the Engineers Club and the Circle Club of St. Louis, the St. Louis Traffic Club, the National Economic League, the Missouri Athletic Association and the Bellerive Country Club. He was a Director in the Missouri Pacific Hospital Association, as well as the Railroad Y.M.C.A. Soon after coming to St. Louis, Mr. Hadley became affiliated with the Pilgrim Congregational Church. He was also a member of Tuscan Lodge, A.F.&A.M., Missouri Consistory No. 1, M.R.S., and Moolah Temple, A.A.O.N.M.S.

Mr. Hadley was married in 1902 to Lilla May Sturtevant, of Lowell. Mass. In addition to Mrs. Hadley he is survived by one son, Carlton Sturtevant, and also by his mother, Mrs. Frank Milan (Lillian Eastman) Hadley of Lowell, Mass., a sister, Mrs. Harrison E. Byam of Lowell, Mass., and a brother, Walter E. Hadley of Maplewood, N. J.

This Association, the Missouri Pacific Railroad, the Engineering Profession at large, and his multitude of friends have suffered a great loss by the passing of Mr. Hadley. All who knew him admired him for his kindly consideration and friendliness. "His cheerful thoroughness, unconsciously but none the less indelibly, impressed you with the feeling that gloom is negative and joy is positive."

COMMITTEE REPORTS

REPORT OF COMMITTEE VII—WOODEN BRIDGES AND TRESTLES

H. AUSTILL, *Chairman;*
F. E. BATES,
L. R. BOETTCHER,
H. M. BUELL,
C. R. CHEVALIER,
H. M. CHURCH,
F. H. CRAMER,
W. R. EDWARDS,
T. H. GARDNER,
S. F. GREAR,
R. W. GUSTAFSON,
R. P. HART,
W. E. HAWLEY,
C. J. HOGUE,
R. W. KENNEDY,
J. A. NEWLIN,
W. L. PEOPLES,
D. W. SMITH, *Vice-Chairman;*
G. W. REAR,
ARTHUR RIDGWAY,
H. T. RIGHTS,
W. R. ROOF,
W. J. RYAN,
G. C. TUTHILL,
J. L. VOGEL,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual.

(2) Simplification of grading rules and classification of timber for railway uses, collaborating with other organizations dealing with this subject.

(3) Overhead wooden or combination wooden and steel highway bridges, collaborating with Committees VIII—Masonry and XV—Iron and Steel Structures.

(4) Design of standard wooden trestles for heavy loadings.

(5) Relative merits of concrete and treated wooden trestles, collaborating with Committees VIII—Masonry and XVII—Wood Preservation.

(7) Bearing power of wooden piles, with recommendation as to best methods of determination.

(8) Best relationships between the energy of hammer and the weight or mass of pile for proper pile driving, to include concrete piles, collaborating with Committee VIII—Masonry.

(9) Improved design of timber structures to give longer life with lower cost of maintenance.

(10) Improved methods of strengthening existing bridges.

(11) Design of washers, separators, cap-stringer straps and other trestle fastenings.

Action Recommended

1. That proposed changes in the Manual Appendix A be adopted.
2. That Appendix B be received as information.
3. That Appendix C be received as information.
4. That Appendix D be received as a progress report.
5. That Appendix E be received as information.
7. That Appendix F be received as a progress report.
8. That Appendix G be received as information.
9. That Appendix H be received as a progress report.
10. That Appendix I be received as information.
11. That Appendix J be received as a progress report.

Respectfully submitted,

THE COMMITTEE ON WOODEN BRIDGES AND TRESTLES,

H. AUSTILL, *Chairman.*

Bulletin 349, September, 1932.

Appendix A

(1) REVISION OF MANUAL

D. W. Smith, Chairman, Sub-Committee; F. H. Cramer, Wm. E. Hawley, Arthur Ridgway, G. C. Tuthill.

Your Committee recommends the following changes in the Manual:

As in the 1929 Manual

Page 450—Definitions

SCREW PILE.—One having a broad-bladed screw attached to its foot to provide a larger bearing area.

Revision Recommended

SCREW PILE.—One having a broad-bladed metal screw attached to its foot to aid in penetration and to provide a larger bearing area.

As in the 1929 Manual

Page 459

(3) If properly handled in the creosoting plants, the strength of the timber is not materially reduced and can be used with the same working stresses as untreated timber.

Revision Recommended

(3) If properly handled in the treating plants, the strength of the timber is not materially reduced and can be used with the same working stresses as untreated timber of the same grade and conditions of exposure.

As in the 1929 Manual

Page 470

12. Southern pine and Douglas fir piles shall have the following limiting dimensions:

	Diameter 3 ft. from Butt		*Diameter of Tip*
Length	*Min.*	*Max.*	*Min.*
Under 40 ft.	14 in.	18 in.	10 in.
40 ft. to 50 ft.	14 in.	18 in.	9 in.
50 ft. to 70 ft.	14 in.	18 in.	8 in.
70 ft. to 90 ft.	14 in.	18 in.	7 in.
Over 90 ft.	14 in.	20 in.	6 in.

Revision Recommended

Under 40 ft.	14 in.	18 in.	10 in.
40 ft. to 50 ft.	14 in.	18 in.	9 in.
50 ft. to 70 ft.	14 in.	18 in.	8 in.
70 ft. to 90 ft.	14 in.	20 in.	7 in.
Over 90 ft.	14 in.	22 in.	7 in.

As in the 1929 Manual

Page 505

Sizes of Joist and Plank

Joist, Rafters, Scaffold Plank, Factory Flooring, etc.

Nominal thickness:	2″ to 4″
Nominal widths:	4″ and wider
Standard thickness:	S1S or S2S: 3/8″ off
Standard widths:	4″ to 7″, S1E or S2E : 3/8″ off
	8″ and wider, S1E or S2E : 1/2″ off

Revision Recommended

Sizes of Joist and Plank

Joist, Rafters, Scaffold Plank, Factory Flooring, etc.

Standard nominal thicknesses	2, 2½, 3, and 4 in.
Standard nominal widths	4 in. and wider in multiples of 2 in.
Standard dressed thicknesses, S1S or S2S	⅜ in. off [a]
Standard dressed widths, S1E or S2E	4 to 7 in., ⅜ in. off [a] 8 in. and wider, ½ in. off [a]

As in the 1929 Manual

Page 505

Sizes of Beams and Stringers

Beams, Girders, Stringers, etc.

Nominal thickness:	5″ and thicker
Nominal widths:	8″ and wider

Revision Recommended

Sizes of Beams and Stringers

Beams, Girders, Stringers, etc.

Standard nominal thicknesses	5 in., 6 in., and thicker in multiples of 2 in.
Standard nominal widths	8 in. and wider in multiples of 2 in.
Standard dressed sizes, S1S, S1E, S2S, or S4S	½ in. off [a]

As in the 1929 Manual

Sizes of Posts and Timbers

Posts, Caps, Sills, Timbers, etc.

Nominal sizes:	6″ × 6″ and larger

Revision Recommended

Sizes of Posts and Timbers

Posts, Caps, Sills, Timbers, etc.

Standard nominal sizes	6″ × 6″ and larger in multiples of 2 in.
Standard dressed sizes, S1S, S1E, S2S, or S4S	½ in. off [a]

[a]Lumber is dressed by running it through a planer and may be surfaced on one side (S1S), surfaced on two sides (S2S), surfaced on one edge (S1E), surfaced on two edges (S2E), or surfaced on a combination of sides and edges, (S1S1E), (S2S1E), (S1S2E), or (S4S). The standard minimum dressed dimension is the nominal size less the allowance for surfacing. In addition to providing a smooth surface, a further purpose in dressing lumber is to bring each piece to standard uniform dimensions throughout its length, and also to bring all pieces to the same dimensions. For these reasons, and because of the method of manufacture and planing, the allowance for surfacing is the same regardless of whether one or two opposite faces are surfaced. If a 2 by 8 in. joist is S1S or S2S, the minimum dressed thickness is 1⅝ in., the width remaining the standard rough dimension; that is, the nominal width of 8 in., subject to the slight variation in sawing permitted (Par. 1B); if S1E or S2E the minimum dressed width is 7½ in., the thickness remaining the standard rough dimension; that is, the nominal thickness of 2 in., subject to the slight variation in sawing permitted (Par. 1B); and if (S1S1E, S2S1E, S1S2E, or S4S), the piece is dressed to the minimum size in both dimensions. The dressed dimensions apply to the moisture condition existing in the piece at the time of dressing, so that any subsequent drying will result in some shrinkage. Whether scantness of size is due to shrinkage or to overdressing may usually be determined by soaking the piece in water. If dressed originally to standard size, the soaked piece will return to at least that size.

As in the 1929 Manual

Page 506

1A. Structural Joist and Plank shall be when surfaced S1S or S2S not thinner than the nominal dimensions less ⅜ inch and when surfaced S1E or S2E not narrower than the nominal width less ⅜ inch for sizes 2 to 7 inches, inclusive, and less ½ inch for sizes 8 inches and wider.

Revision Recommended

1A. Structural joist and plank when S1S or S2S shall be not thinner than the nominal thickness less ⅜ inch, and when S1E or S2E not narrower than the nominal width less ⅜ inch in pieces 4 to 7 inches in width, inclusive, and less ½ inch in pieces 8 inches and wider.

As in the 1929 Manual

Page 506

1B. Rough Structural Joist and Plank shall be not thinner than the nominal dimensions less ¼ inch, and not narrower than the nominal width less ¼ inch for sizes 2 to 7 inches, inclusive, and less ⅜ inch for sizes 8 inches and wider.

Revision Recommended

1B. Rough structural joist and plank shall be sawn full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be thinner than the nominal thickness less ⅛ inch in pieces 2 inches in thickness, and less $\frac{3}{16}$ inch in pieces 3 and 4 inches in thickness, nor narrower than the nominal width less $\frac{3}{16}$ inch in pieces 4 to 7 inches in width, inclusive, and less ¼ inch in pieces 8 inches and wider. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

As in the 1929 Manual

Page 506

2A. Structural Beams and Stringers shall be when surfaced S1S, S1E, S2S or S4S not smaller than the nominal size less ⅜ inch for sizes 7 inches and less, and less ½ inch for sizes 8 inches and over.

Revision Recommended

2A. Structural beams and stringers when S1S, S1E, S2S, or S4S, shall be not smaller than the nominal dimensions less ½ inch.

As in the 1929 Manual

Page 506

2B. Rough Structural Beams and Stringers shall be not smaller than the nominal size less ¼ inch for sizes 7 inches and less, and less ⅜ inch for sizes 8 inches and over.

Revision Recommended

2B. Rough structural beams and stringers shall be sawn full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be smaller than the nominal dimensions less $\frac{3}{16}$ inch in pieces 5 and 6 inches in dimensions, and less ¼ inch in pieces 8 inches and larger. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

As in the 1929 Manual

Page 506

3A. Structural Posts and Timbers shall be when surfaced S1S, S1E, S2S or S4S not smaller than the nominal size less ⅜ inch for sizes 7 inches and less, and less ½ inch for sizes 8 inches and over.

Revision Recommended

3A. Structural posts and timbers when S1S, S1E, S2S, or S4S, shall be not smaller than the nominal dimensions less ½ inch.

As in the 1929 Manual

Page 506

3B. Rough Structural Posts and Timbers shall be not smaller than the nominal size less ¼ inch for sizes 7 inches and less, and less ⅜ inch for sizes 8 inches and over.

Revision Recommended

3B. Rough structural posts and timbers shall be sawn full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be smaller than the nominal dimensions less $\frac{3}{16}$ inch in pieces 6 inches in dimensions and less ¼ inch in pieces 8 inches and larger. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

As in the 1929 Manual

Page 527

2B. Rough Structural Beams and Stringers shall be not smaller than the nominal size less ¼ inch for sizes 7 inches and less, and less ⅜ inch for sizes 8 inches and over.

Revision Recommended

2B. Rough structural beams and stringers shall be sawn full to nominal dimensions, except that occasional slight variation in sawing is permissible. However, at no part of the length shall any piece, because of such variation in sawing, be smaller than the nominal dimensions less $\frac{3}{16}$ inch in pieces 5 and 6 inches in dimensions, and less ¼ inch in pieces 8 inches and larger. Further, no shipment shall contain more than 20 per cent of pieces of minimum dimensions.

As in the 1929 Manual

Page 530

3A. Structural Posts and Timbers shall be when surfaced S1S, S1E, S2S or S4S not smaller than the nominal size less ⅜ inch for sizes 7 inches and less, and less ½ inch for sizes 8 inches and over.

Revision Recommended

3A. Structural posts and timbers when S1S, S1E, S2S, or S4S, shall be not smaller than the nominal dimensions less ½ inch.

As in the 1929 Manual

Page 533

1A. Structural Joist and Plank shall be when surfaced S1S or S2S not thinner than the nominal dimension less ⅜ inch and when surfaced S1E or S2E not narrower than the nominal width less ⅜ inch for sizes 2 to 7 inches, inclusive, and less ½ inch for sizes 8 inches and wider.

Revision Recommended

1A. Structural joist and plank when S1S or S2S shall be not thinner than the nominal thickness less ⅜ inch, and when S1E or S2E not narrower than the nominal width less ⅜ inch in pieces 4 to 7 inches in width, inclusive, and less ½ inch in pieces 8 inches and wider.

Appendix B

(2) SIMPLIFICATION OF GRADING RULES AND CLASSIFICATION OF TIMBER FOR RAILWAY USES

W. E. Hawley, Chairman, Sub-Committee; H. M. Buell, C. R. Chevalier, H. M. Church, C. J. Hogue, R. W. Kennedy, J. A. Newlin.

Some progress is being made by regional lumber associations in developing regional grading rules for structural timber but these have not been advanced far enough to give time for consideration by this Committee, and therefore we have no definite recommendation to report at this time.

Appendix C

(3) OVERHEAD WOODEN OR COMBINATION WOODEN AND STEEL HIGHWAY BRIDGES

R. P. Hart, Chairman, Sub-Committee; F. H. Cramer, R. W. Gustafson, G. W. Rear, G. C. Tuthill, J. L. Vogel.

Study of this subject has been continued but sufficient progress has not been made to permit presenting any new plans this year.

Attention is directed to two articles by Conde B. McCullough, Bridge Engineer, Oregon State Highway Commission, concerning developments in timber highway bridge construction; the first appearing in Civil Engineering, Vol. 2, No. 9, September, 1932, entitled "Modern Short-Span Bridges", and the second appearing in Engineering-News Record, Vol. 109, No. 8, August 25, 1932, entitled "Timber Highway Bridges in Oregon".

Appendix D

(4) DESIGN OF STANDARD WOODEN TRESTLES FOR HEAVY LOADINGS

F. E. Bates, Chairman, Sub-Committee; H. M. Church, W. R. Edwards, J. A. Newlin, W. R. Roof, W. J. Ryan, D. W. Smith.

The Committee proceeded with a study of the subject but has no definite report to make at this time.

Appendix E

(5) RELATIVE MERITS OF CONCRETE AND TREATED WOODEN TRESTLES

Arthur Ridgway, Chairman, Sub-Committee; F. E. Bates, F. H. Cramer, S. F. Grear, C. J. Hogue, R. W. Kennedy, G. W. Rear.

The efforts of the Committee this year have been directed largely towards the obtaining of data as to the cost of maintenance of treated wooden trestles.

Recorded costs of repairs for about 175 bridges of various heights, lengths, and ages have been assembled. There have also been collected reliable data on the cost of concrete trestles.

Notwithstanding the vast amount of study and investigation the Committee has devoted to the subject, it is not in a position to report definite conclusion in the matter at this time.

Appendix F

(7) BEARING POWER OF WOODEN PILES, WITH RECOMMENDATION AS TO BEST METHODS OF DETERMINATION

W. R. Edwards, Chairman, Sub-Committee; L. R. Boettcher, H. M. Buell, G. W. Rear, W. J. Ryan, G. C. Tuthill, J. L. Vogel.

The Committee invites attention to an article on "Tests of Model Piles," by L. C. Wilcoxen, Assistant Civil Engineer, City Engineer's Office, Detroit, Michigan, appearing in Engineering News-Record, November 3, 1932.

The Committee has continued the collection of such data as has been found to be available, but is not prepared at this time to submit any conclusions.

Appendix G

(8) BEST RELATIONSHIPS BETWEEN THE ENERGY OF HAMMER AND THE WEIGHT OR MASS OF PILE FOR PROPER PILE DRIVING, TO INCLUDE CONCRETE PILES

C. R. Chevalier, Chairman, Sub-Committee; J. H. Gardner, R. W. Gustafson, W. L. Peoples, H. J. Rights, W. J. Ryan.

The first report on this subject was made at the 1932 Convention, and appears in the November 1931 Bulletin, pages 255 to 257. Nothing since has come to the attention of the Committee to cause any material change in the conclusions therein reported.

Exhibit "A" of Appendix G of the above report should be revised as follows:

Line one, column eleven, insert 35 in blank space.

Change total of column thirteen from 60.47 to 51.56.

Change average of column thirteen from 2.08 to 2.24.

Additional data collected by the Committee is given in Exhibit "A".

During the summer of 1932, the Bridge Department of the Missouri Pacific Railroad conducted tests at North Little Rock, Ark., three piles of the same length being driven to the same penetration, this being a depth where it was expected further penetration or settlement could be secured by a superimposed load. The results of this test are given in Exhibit "B". It appears from this test and from tests made at Kansas City, Mo., in 1912 that the commonly used Engineering News formula does not always give a very large factor of safety.

The Committee invites attention to a paper by Roland Bennett, on "Pile-Driving and the Supporting Capacity of Piles," published by the Institution of Civil Engineers, London, England, in 1931.

Exhibit B

Kind of Pile	*Creosoted Pine*	*Concrete*	*Concrete*
Length of Pile, in feet	20	20	20
Diameter, in inches	Butt 15 Tip 12 Av. 13½	16	24
Area of cross-section in square inches	143	212	480
Perimeter, in feet	3.534	4.417	6.667
Penetration, in feet	18.5	18.5	18.5
Area in contact with soil, square feet	66	76	112
Weight of Pile, in pounds	1,320	4,400	10,000
Energy of hammer, in foot-pounds	15,000	15,000	24,375
Weight of hammer	9,600	9,600	16,250
Weight of pile cap, in pounds	1,200	1,200	5,000
Thickness of Wood Cushion, in inches	0	2	2
Average penetration, last few blows, in inches	3/4	3/5	3/7
Safe load, by Engr. News formula, in tons	17.6	21.4	46.0
Superimposed load at beginning of test, in tons	5	10	20
Load giving first indication of settlement, in tons	5	10	32
Final load to obtain equal settlement, in tons	44	61	94
Total settlement under final load, in feet	0.069	0.063	0.065
Spring up after load was removed, in feet	0.014	0.014	0.012
Per cent—area of cross-section	100	148.2	335.7
Per cent—perimeter	100	125	188.7

Exhibit "A" to Appendix G

lroad	Location	Structure	Kind	Pile Length in feet	Pile Weight in Lbs.	Hammer Type	Hammer Weight Hammer in Lbs.	Hammer Weight Ram in Lbs.	Hammer Length Stroke Ins.	Hammer Strokes per min.	Hammer Energy in Foot Lbs.	Ft. Lbs. Energy Divided by Wt. of Pile in Lbs.	Remarks
.Co.	Longview, Wash.	Cargo Dock	Doug. Fir-Utr.	80	3760	Single Acting	9600	5000	36	60	15000	3.99	Satisfactory-1800 Driven-Penetration18'
	" "	" "	Cedar "	60	2080	" "	9600	5000	36	60	15000	7.43	" 1665 " " 20'
	" "	" "	" "	50	1800	" "	6700	3000	29	70	7260	4.03	" 80 " " 25'
	" "	" "	Doug. Fir "	55	2255	Double "	6750	1500	16	120	5940	2.63	" 40 " " 25'
	" "	" "	" "	70	2870	" "	6750	1500	16	120	5940	2.07	Light 10 " " 18'
	" "	" "	" "	80	2620	" "	6750	1500	16	140	8200	3.13	Satisfactory 140 " " 28'
	" "	Foundation	" "	60	2475	Single "	9600	5000	36	60	15000	6.06	" Jetted 35' " 58'
	" "	"	" "	60	2475	" "	9600	5000	36	60	15000	6.06	" Not Jetted " 60'
Pac.	Arkansas	Trestle	Conc. 24"	20	10000	" "	16250	7500	39	50	24375	2.44	
	"	"	"	25	12500	" "	16250	7500	39	50	24375	1.95	
	"	"	"	30	15000	" "	16250	7500	39	50	24375	1.63	1" in 20 blows " 18'
	"	"	"	35	17500	" "	16250	7500	39	50	24375	1.39	
	"	"	"	40	20000	" "	16250	7500	39	50	24375	1.22	115 Tons Load-1" in 4½blows " 20'
	"	"	"	45	22500	" "	16250	7500	39	50	24375	1.08	
	"	"	"	50	25000	" "	16250	7500	39	50	24375	0.97	
	"	"	Conc. 16"	30	6600	" "	9600	5000	36	60	15000	2.27	1" in 20 " " 18'
												48.35	
												3.07	Average - This Sheet

48.35 Summation - This Sheet
51.56 " - Previous Sheet
99.91
2.53 Average - Both Sheets - Steam Hammers.

Per cent—area in contact with soil	100	115	170
Per cent—supporting power by Engr. News formula	100	121.6	261.4
Per cent—final superimposed loads, equal settlement	100	138.7	213.7
Energy, in foot-pounds divided by weight of pile in pounds	11.36	3.41	1.22
Second Driving to determine "set"			
Energy of hammer, in foot-pounds	...	24,375	24,375
Number of blows to start pile	...	3	3
Average penetration, last few blows, in inches	...	1/3	1/5
Safe load, by Engr. News formula, in tons	...	56	81
Energy, in foot-pounds divided by weight of pile in pounds	...	5.54	1.22

Piles driven May 27, 1932; ground was saturated with water to fill any voids around piles caused by driving. Loading began June 8 and was continued until July 19, after which no settlement occurred. Began removing loads July 25. Second driving done August 25, 1932.

Appendix H

(9) IMPROVED DESIGN OF TIMBER STRUCTURES TO GIVE LONGER LIFE WITH LOWER COST OF MAINTENANCE

F. H. Cramer, Chairman, Sub-Committee; F. E. Bates, L. R. Boettcher, H. M. Buell, H. M. Church, J. A. Newlin, W. L. Peoples.

The Committee reports progress.

Appendix I

(10) IMPROVED METHODS OF STRENGTHENING EXISTING BRIDGES

S. F. Grear, Chairman, Sub-Committee; W. R. Edwards, T. H. Gardner, R. P. Hart, W. L. Peoples, H. T. Rights, W. R. Roof.

In preparing this report, it is assumed that the intent is to outline methods of changing structures to a heavier type and not to cover ordinary repairs. This will cover only wooden trestles.

The strengthening of old structures should be done in a manner to bring them as nearly as possible to the established standard for the district.

Standard materials must be used to the fullest possible extent to avoid the necessity of carrying special sizes for repairs.

In general, treated and untreated materials must not be mixed in the same structure.

Any additional piles or posts placed in a bent should be placed as closely as possible under the rails. This puts the new bearing where it gets the direct load and where it strengthens the existing cap.

When additional stringers are necessary, the old stringers must be loosened and respaced so that the stringers as a unit are symmetrical about the center line of the rail. New stringers must be bolted to the old stringers.

Cross bracing must be changed so that it will be fastened to the new members of the bent.

Any bolt holes left in treated material must be swabbed with hot creosote oil and filled with treated plugs; any cut surfaces in treated material must be painted with hot creosote oil.

The above methods will, in general, preclude the necessity of putting in heavier caps and ties.

Where strengthening is due to causes other than design, different methods are required.

A frequent source of trouble is the lack of proper bearing power of piles. This condition may be remedied, in some cases, by posts on sills but this is a makeshift and is to be considered only as a temporary arrangement.

Where waterway conditions permit, helper bents will strengthen both the bents and stringers and can generally be so spaced as to become part of a replacement structure.

Trestles which must be raised to have three or more caps should have outside batter piles driven in line with each bent, and the top cap made long enough to reach the tops of these batter piles. These piles serve to stiffen the trestle both laterally and longitudinally. Bracing must be changed so as to be attached to all caps.

When additional piles in the line of the bent are required to carry the load, double caps must be used where necessary to distribute the load.

It is the recommendation that this report be received as information.

Appendix J

(11) DESIGN OF WASHERS, SEPARATORS, CAP-STRINGER STRAPS AND OTHER TRESTLE FASTENINGS

R. W. Gustafson, Chairman, Sub-Committee; L. R. Boettcher, T. H. Gardner, R. P. Hart, R. W. Kennedy, J. L. Vogel, H. T. Rights, W. R. Roof.

The Committee has collected the standard design plans of a number of the larger railroads to use as a basis of study of the subject.

The Committee reports progress but has been unable to make sufficient study for preparation of a report.

REPORT OF COMMITTEE XII—RULES AND ORGANIZATION

E. H. BARNHART, *Chairman;*
F. W. ARMISTEAD,
M. M. BACKUS,
W. C. BARRETT,
D. P. BEACH,
L. D. BEATTY,
RICHARD BROOKE,
H. L. BROWNE,
P. D. COONS,
W. O. CUDWORTH,
J. L. DOWNS,
J. T. FITZGERALD,
H. W. GRAHAM,
A. B. GRIGGS,
H. C. HAYES,
E. G. HEWSON,
A. A. JACKSON,
A. R. JONES,
R. E. WARDEN, *Vice-Chairman;*
B. R. KULP,
W. C. MACK,
H. A. MARCH,
F. R. PUDER,
W. A. RADSPINNER,
W. B. STIMSON,
C. B. TELLER,
F. B. WIEGAND,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of Manual, collaborating with appropriate committees (Appendix A).

The Committee offers for approval and printing in the Manual the changes outlined in Appendix A, the same to be substituted for the existing subject matter.

2. Rules for the guidance of employees of the Maintenance of Way Department, with special reference to:

(a) Maintenance of bridges collaborating with Committee VIII—Masonry, and XV—Iron and Steel Structures (Appendix B).
(b) Maintenance of telegraph and telephone lines and appurtenances, collaborating with committee appointed by Telegraph and Telephone Section.
(c) Maintenance of terminal structures other than buildings, collaborating with Committee XIV—Yards and Terminals and XXIII—Shops and Locomotive Terminals (Appendix C).

2–a. The Committee offers for approval and printing in the Manual Rules 1150 to 1165 inclusive, as shown in Appendix B—Rules for Maintenance of Bridges—Masonry and composite structures. These rules have the approval of Committees VIII—Masonry and XV—Iron and Steel Structures.

2–b. The Sub-Committee having in charge the preparation of rules for maintenance of telegraph and telephone lines and appurtenances has had no meeting this year with the representatives of the Telegraph and Telephone Section. An agreement reached last year to the effect that the committee of the T&T Section would draft from their Manual such rules which properly belonged to Maintenance of Way employees was not fulfilled by the T&T committee, as such rules were not submitted to the Sub-Committee.

2–c. The Committee offers for approval and printing in the Manual Rules 1278–1289 and 1299 as shown in Appendix C, Rules for Maintenance of Terminal Structures other than Buildings. These rules have the approval of Committees XIV—Yards and Terminals and XXIII—Shops and Locomotive Terminals.

3. Titles employed to designate positions of corresponding rank in Maintenance of Way service subordinate to that of Division Engineer, recommend appropriate titles for position known as "Assistant Engineer" in all departments, considering the duties involved.

The Committee has given considerable study and analyzed very thoroughly the information obtained through a questionnaire last year and presents for information data shown in Appendix D, with the special request that members of the Association who are interested in clearing up this very confusing use of the title give earnest thought and consideration to the recommendations and communicate with the

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Bulletin 349, September, 1932.

Committee during the ensuing year. A large number of replies would indicate a widespread interest in this very interesting subject and better enable the Committee to make definite recommendations for printing in the Manual.

4. Rules for fire prevention as applying to the Maintenance of Way Department, collaborating with the Railway Fire Protection Association and National Board of Fire Underwriters.

The Committee offers as information in Appendix E a number of rules on fire prevention. The rules offered last year for information have been carefully gone over and revised by the Committee and these rules have the approval of the National Board of Fire Underwriters. The Committee hopes to be in position next year to secure the approval of all interested bodies and be able to present a recommendation for approval and printing in the Manual.

Respectfully submitted,

THE COMMITTEE ON RULES AND ORGANIZATION,

E. H. BARNHART, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

P. D. Coons, Chairman Sub-Committee

RULES FOR INSPECTION OF BRIDGES, TRESTLES AND CULVERTS (p 847)

Rule 1353.

Present Form

These bridge inspectors shall forward to the ....in (duplicate) (triplicate)..........on the proper form provided, a report of each bridge, trestle or culvert inspected, enumerating in detail the parts of each structure inspected, giving the conditions found in each individual part. One of these forms must be forwarded for each structure inspected, and shall be complete in itself, showing the actual conditions as found, regardless of what may have previously been reported. These reports must be forwarded at the end of each day's inspection.

Rule 1353.

Proposed Form

These bridge inspectors shall forward to the ....in (duplicate) (triplicate)..........on the proper form provided, a report of each bridge, trestle or culvert inspected, giving the conditions found. One of these forms must be forwarded for each structure inspected, and shall be complete in itself, showing the actual conditions as found, regardless of what may have previously been reported. These reports must be forwarded at the end of each day's inspection.

Rule 1415.

(Page 859)

Present Form

*FORMS

1415. Form to be used by Division Bridge Inspector for general inspection of all bridges, trestles and culverts should be printed in books of 100 or more leaves, each leaf being perforated and having a carbonized back. The backs of the books should be stiff cardboard or linen and size should not exceed 4½ inches by 6½ inches.

* Forms not yet submitted.

Rule 1415.

Proposed Form

Withdrawn in its entirety.

Appendix B

(2-A) RULES FOR MAINTENANCE OF BRIDGES—MASONRY

A. B. Griggs, Chairman, Sub-Committee.

1150. Driftwood or other débris must not be permitted to accumulate around the base of bridge masonry.

1151. All obstructions to proper drainage in the channel must be removed. If obstructions are caused by a faulty channel, the obstruction should be removed by changing the channel.

1152. Where any scouring or undermining of bridge masonry is found, riprap or other forms of protection must be installed.

1153. Where foundations are badly undermined or the relative elevation of the stream bed and the bottom of the masonry are not considered proper, the foundation should be lowered.

1154. Where examination reveals weakness of masonry on account of undersize of foundation, the dimensions of same must be increased as required for safe loadings.

1155. Where arches or culverts have been subjected to excessive scouring or undermining additional protection should be provided in the form of paving, inverts, apron or curtain walls.

1156. Where masonry is subjected to the action of ice or other abrasion causing disintegration, protection work of proper design must be installed and the masonry repaired.

1157. Where masonry is founded on timber, previously under water which subsequently becomes exposed to the air, proper masonry foundation must be substituted or the structure removed and rebuilt.

1158. Where movement has become restricted at expansion joints, they must be repaired to allow the joints to function as designed.

1159. Where failure of arch rings occur as indicated by cracks or flattening of the arch, temporary support must be provided until permanent repairs can be made.

1160. Drains or "weep holes" in bridge masonry must be kept open to insure full operation of the drainage system.

1161. Inadequate drainage of bridge masonry should be remedied by installation of drain tile or pipe.

1162. Bridge seats that have become weakened through deterioration or overload must be replaced with approved quality of reinforced concrete or granite masonry. Engineering plans to cover each case will be furnished.

1163. Areas of masonry that have become deteriorated must be repaired prior to reaching an extent endangering the strength of the structure. These areas must be repaired with good quality concrete, observing specifications for repairing deteriorating concrete.

1164. Stone or concrete structure showing deterioration over a large part of the surface, or which is otherwise structurally weak, must be rebuilt or be reinforced by an encasement of good quality concrete in accordance with approved plans.

1165. Joints in stone masonry must be kept well pointed. Before pointing, all loose material must be removed and the joints well-moistened.

Appendix C

2 (C) RULES FOR MAINTENANCE OF TERMINAL STRUCTURES OTHER THAN BUILDINGS

B. R. Kulp, Chairman, Sub-Committee.

Turntables

1278. Turntables must be given close inspection at regular intervals.

1279. Careful maintenance must be given at all times by each Department assigned to various units. The center pier must be kept level, firm and unyielding.

1288. Circle rails must be kept in correct surface and alignment.

1289. Track rails must be in good surface, anchored against end movement and properly supported at the ends of tables.

Oil Houses

1299. Repairs must not be made with open flame lights, and in no case until investigation has been made to determine that there do not exist any oil or gas fumes.

Appendix D

(3) APPROPRIATE TITLES FOR ASSISTANT ENGINEERS

Richard Brooke, Chairman, Sub-Committee.

	Duties of Position	*Reporting to*	*Proposed Title*
(1)	In charge of office engineering work in office of Chief Engineer	Chief Engineer or Assistant Chief Engineer	Office Engineer
(2)	Special investigations, studies, estimates and reports	Chief Engineer or Assistant Chief Engineer	Special Engineer
(3)	In charge of reconnaissance and of location on an entire system, or region of a large system	Chief Engineer	Locating Engineer
(4)	In charge of a reconnaissance or location on a specific project	Locating Engineer	Assistant Locating Engineer
(5)	In charge of construction on an entire system, or region of a large system	Chief Engineer	Construction Engineer
(6)	In charge of large construction projects	Construction Engineer	Assistant Construction Engineer
(7)	In charge of a specific project, such as ten miles of new line or equivalent	Construction Engineer or Assistant Construction Engineer	Resident Engineer
(8)	General inspection of construction work	Construction Engineer	Construction Inspector.
(9)	In charge of office engineering work in office of Construction Engineer	Construction Engineer	Office Engineer, Construction
(10)	Special maintenance investigations	Chief Maintenance Officer	Special Engineer Maintenance
(11)	*Preparation of plans and estimates and supervision of field and office engineering work	Division Engineer	Assistant Engineer, Maintenance
(12)	Inspection of track and roadbed	Chief Maintenance Officer or an Assistant	Maintenance Inspector
(13)	Inspection of bridges and/or buildings on an entire system, or region of a large system	Chief Maintenance Officer or Bridge Engineer and/or Building Engineer	General Bridge and/or Building Inspector
(14)	Special bridge and/or building investigations, studies, estimates and reports	Chief Maintenance Officer or Bridge Engineer and/or Building Engineer	Special Engineer, Bridges and/or Buildings
(15)	Bridge design (particular (projects)	Bridge Engineer or an Assistant	Bridge Designer
(16)	Bridge erection on a specific project	Bridge Engineer	Assistant Engineer, Bridge Erection
(17)	Building design and erection	Building Engineer	Assistant Engineer, Buildings
(18)	Water service, design, construction and/or maintenance	Chief Water Service Officer	Assistant Engineer, Water Service
(19)	Miscellaneous valuation work	Valuation Engineer	Assistant Engineer, Valuation

* This title was adopted by the Convention in March, 1931, and printed in Bulletin 347, page 29 (Revisions and Additions to the Manual).

Appendix E

(4) RULES FOR FIRE PREVENTION AS APPLYING TO MAINTENANCE OF WAY DEPARTMENT

H. C. Hayes, Chairman, Sub-Committee.

General

33. Employees must give full co-operation to Fire Prevention measures.

Division Engineers

302. They must see that employees under their jurisdiction are properly instructed in fire prevention rules, alert in decreasing fire hazards and exacting in the maintenance and operation of fire fighting apparatus. When locating buildings and structures they will see that attention is given fire prevention.

Supervisors of Track

316. They must give particular attention to fire hazards from adjoining property and from structures erected on railway property by lessees.

317. They must see that those under their supervision do not obstruct fire roads, fire hydrants and hose houses.

318. They must see that no lumber, ties, piling or other inflammable materials are piled within fifty (50) feet of any important building and that automobiles or trucks are not parked in a manner which constitutes a fire hazard.

319. They must know that their Foremen understand and observe fire prevention rules.

Supervisors of Bridges and Buildings

374. They must give particular attention to fire hazards where the risk is extreme, such as oil houses, paint shops, wood coal chutes, and cotton platforms.

375. They must make proper reports to superiors of any unguarded fire hazards.

376. They must see that those under their supervision do not obstruct fire escapes and exit passages thereto, fire doors, hose reels, fire hydrants, fire roads, and hose houses.

377. They must see that those under their supervision are familiar with the location and use of the nearest fire alarms.

378. They must see that all sprinkler systems and fire lighting apparatus are maintained in accordance with the regulations of the National Board of Fire Underwriters.

379. They must arrange for the proper co-operation of all municipal fire departments.

379–A. They must make recommendations for necessary fire walls, doors, shutters, and for the removal of any fire hazards.

379–B. They must know that their Foremen understand and observe fire prevention rules.

379–C. They must see that inflammable materials are stored so as to confine any fire to the place of origin.

Supervisors of Water Service

423. They must know that fire pumps and fire lines are in working condition and able to deliver sufficient volume of water to quench any fire on the property. They must see that fire hydrants and hose are always ready for instant use.

424. They must see that where possible proper connections are made to all municipal fire mains.

425. They must know that their Foremen understand and observe fire prevention rules.

REPORT OF COMMITTEE XIII—WATER SERVICE AND SANITATION

R. C. Bardwell, *Chairman;*
W. R. Anthony,
W. M. Barr,
R. W. Chorley,
R. E. Coughlan,
W. L. Curtiss,
J. H. Davidson,
B. W. DeGeer,
A. F. Dorley,
R. N. Foster,
C. H. Fox,
J. H. Gibboney,
W. P. Hale,
J. P. Hanley,
L. A. Henry,
R. L. Holmes,
J. R. Hickox,
A. W. Johnson,
H. F. King,
C. R. Knowles,
P. M. LaBach,
J. J. Laudig,
W. B. McCaleb,
W. A. McGee,
H. L. McMullin,
W. B. Nissly,
A. B. Pierce,
O. T. Rees,
E. M. Grime, *Vice-Chairman;*
J. A. Russell,
H. E. Silcox,
D. A. Steel,
R. M. Stimmel,
R. A. Tanner,
W. O. Towson,
F. P. Turner,
C. P. VanGundy,
H. W. VanHovenberg,
J. B. Wesley,
A. E. Willahan,
R. S. Wilson,
Committee.

To the American Railway Engineering Association:

Your Committee on Water Service and Sanitation reports on the following subjects:

(1) Revision of Manual (Appendix A). It is recommended that the report as outlined in Appendix A be adopted for publication in the Manual.

(3) Methods and value of water treatment with respect to estimating and summarizing possible savings effected (Appendix B). It is recommended that the report be received as information.

(4) Methods for reporting annual summary water station and treating plant operation (Appendix C). It is recommended that the report be received as information.

(5) Development of deep well pumping equipment (Appendix D). It is recommended that the report as shown in Appendix D be received as information.

(7) Standard methods for analyses of chemicals used in water treatment (Appendix E). Recommended that the report as shown in Appendix E outlining standard methods for analysis of hydrated lime and soda ash be adopted as recommended practice and included in the Manual.

(8) Progress being made by Federal and State authorities on regulations pertaining to railway sanitation, collaborating with the Joint Committee on Railway Sanitation, A. R. A. (Appendix F). Recommended that the report as shown in Appendix F be received as information.

(9) Sewage disposal where sanitary facilities are not available (Appendix G). Recommended that the report be received as information.

Progress is reported on the following subjects:

(2) Pitting and corrosion of boiler tubes and sheets.

(6) Design and maintenance of track pans for locomotive water supply.

Respectfully submitted,

The Committee on Water Service and Sanitation,
R. C. Bardwell, *Chairman.*

Bulletin 349, September, 1932.

•STANDARD THICKNESS AND WEIGHTS OF CAST IRON PIPE

Table No. 2 Classes A, B, C, D

Nominal Inside Diameter Inches	CLASS A 100-Feet Head 43 Pounds Pressure			CLASS B 200-Feet Head 86 Pounds Pressure			CLASS C 300-Feet Head 130 Pounds Pressure			CLASS D 400-Feet Head 173 Pounds Pressure			Nominal Inside Diameter Inches
	Thickness Inches	Weight per Foot	Weight per Length	Thickness Inches	Weight per Foot	Weight per Length	Thickness Inches	Weight per Foot	Weight per Length	Thickness Inches	Weight per Foot	Weight per Length	
4	42	20 0	240	45	21 7	260	43	23 3	280	52	25 0	300	4
6	44	30 8	370	48	33 3	400	51	35 8	430	55	33 3	460	6
8	46	42 9	515	51	47 5	570	56	52 1	625	60	55 8	670	8
10	50	57 1	685	57	63 8	765	62	70 8	850	68	76 7	920	10
12	54	72 5	870	62	82 1	985	68	91 7	1100	75	100 0	1200	12
14	57	89 6	1075	66	102 5	1230	74	116 7	1400	82	129 2	1550	14
16	60	108 3	1300	70	125 0	1500	80	143.8	1725	89	158.3	1900	16
18	64	129 2	1550	75	150 0	1800	87	175 0	2100	96	191 7	2300	18
20	.67	150 0	1800	80	175 0	2100	92	208 3	2500	1 03	229 2	2750	20
24	.76	204 2	2450	89	233.3	2800	1 04	279.2	3350	1.16	306.7	3680	24
30	88	291 7	3500	1.03	333 3	4000	1 20	400.0	4800	1 37	450 0	5400	30
36	99	391 7	4700	1 15	454.2	5450	1.36	545.8	6550	1 58	625 0	7500	36
42	1 10	512 5	6150	1 28	591 7	7100	1.54	716 7	8600	1 78	825 0	9900	42
48	1 26	666 7	8000	1 42	750.0	9000	1 71	908.3	10900	1.96	1050.0	12600	48
54	1 35	800 0	9600	1 55	933.3	11200	1 90	1141 7	13700	2 23	1341 7	16100	54
60	1 39	916 7	11000	1 67	1104 2	13250	2 00	1341.7	16100	2.38	1583 3	19000	60
72	1 62	1283.4	15400	1 95	1545 8	18550	2.39	1904.2	22850	..	..	..	72
84	1 72	1633 4	19600	2 22	2104 2	25250	..	..	..	..	..	..	84

The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

Appendix B

(3) METHODS AND VALUE OF WATER TREATMENT WITH RESPECT TO ESTIMATING AND SUMMARIZING POSSIBLE SAVINGS EFFECTED

R. E. Coughlan, Chairman, Sub-Committee; W. M. Barr, R. W. Chorley, W. L. Curtiss, J. H. Davidson, R. N. Foster, J. P. Hanley, J. H. Gibboney, J. R. Hickox, R. L. Holmes, P. M. LaBach, R. M. Stimmel, W. O. Towson, H. W. Van Hovenberg, J. B. Wesley.

In the report of 1931 your Committee endeavored to furnish available information regarding the various methods of eliminating maintenance of boilers when using water containing varying amounts of incrusting solids.

It should be understood that there is no fixed rule as to the application of any of the methods outlined in any of the previous reports, because of the fact that after compiling such information as is available up to the present time the Committee is of the opinion that each installation of water treatment or water treating facilities should be made only after a thorough survey of each individual water station has been completed.

The available water in the district as well as the operating conditions under which the water is to be used must be considered. Such a survey and recommendation of treatment is of little value unless the Motive Power Department, as well as the Operating Department, is freely consulted and their co-operation obtained.

There is no question but what there is a large field for all of the recognized methods of water treatment outlined in previous reports. The main question to be determined under present-day operation is which method is most suitable with regard to results obtained for the capital invested as well as which method gives the most satisfactory results with a minimum of operating costs.

Practically all natural water used for steam generation can be improved by some form of treatment. The amount and character of the incrusting solids as well as the importance of the water station should determine the method of treatment. The quality of softened water must also be considered, as it is false economy to soften water of such high scaling content that the softened water is unfit for locomotive boiler use because of its high foaming tendency, especially when used with other water of the same district. In some cases it is advisable to change the source of supply before any method of treatment is considered.

During the past year your Committee has asked all Class I railroads to furnish information as to just what improvements might be attributed to water treatment from which a monetary value might be calculated.

The replies give confirming evidence from actual observation before and after treatment, showing that there is a definite improvement.

A summary of the characteristic replies obtained shows:—

1. Records show that boiler work has decreased 50 per cent and that locomotives are no longer shopped for boiler work alone. Previous to correcting water condition the service was unreliable and it was often necessary to use two locomotives per train. Boilers were frequently washed every trip, whereas they now operate from 15 to 30 days.
2. Prior to installation of water treatment, scale and corrosion were very bad. Boilers were washed on some districts every 100 miles, whereas they now operate from 400 to 1,000 miles before washout. Treatment has also decreased the corrosion.
3. Life of boiler material increased over 100 per cent with a reduction of 86 per cent in actual boiler maintenance costs since water treatment has been installed.

4. Boiler maintenance reduction over 80 per cent. Locomotive boiler failures practically eliminated and governed extensions being obtained on many locomotives which have been operating the full four year allowance. Increased mileage between washouts results in a net saving of over $2,000 per month in labor costs alone.
5. Estimate $1,000,000 per year saving due to water treatment.
6. 95 per cent of firebox renewals have been eliminated and life of boiler flues extended over 200 per cent since water treatment has been installed.

Practically all the information furnished at this time confirms the findings of this Committee given in the report of 1925 Vol. 26. Since 1925 more railroads have gone into the question of water treatment more thoroughly and the legitimate boiler compounds and treatment of known compositions have been replacing the "cure-all" treatments of earlier days in railroad service.

Five methods of water treatment are in use on the railroads of today:

(1) Lime and Soda Ash complete treatment with and without coagulent.
(2) Zeolite treatment.
(3) Boiler compound.
(4) Soda Ash.
(5) Sodium Aluminate liquid treatment.

These are in fact the only recognized treatments now in use.

The additional information obtained at this time shows that since the 1925 report was published, savings which were intangible at that time are now becoming more apparent. One of the most pronounced of these is the actual extension of time granted by the Federal Bureau of Steam Locomotive Inspection, which bureau has granted many extensions of one year additional to locomotive boilers which have operated four years. Actual inspection of these boilers show them to be in such excellent condition that there is no hesitancy on the part of the inspector to allow these locomotives to continue to operate for another year. This monetary saving can be easily calculated by extending the actual shopping cost of this class of boiler work. Another apparent saving having a decided monetary value is in the extended mileage operated between washouts. Where the former practice was the washing of boilers every 200 to 800 miles, most railroads now operate from 1,000 to 3,000 miles between washouts and in some cases as high as 5,000 to 6,000 miles are on record. This would be a physical impossibility without some form of water treatment to correct the incrusting solids in the natural water.

The question has also arisen as to the advisability of changing the figure previously reported as 13 cents as the value of one pound of scale removed from water for boiler use before the water is supplied for use. If this figure is used with judgment it is found to be a conservative estimate. In many cases it has been found to be too low. It is true that this figure cannot be accurately used on water containing mostly sulphates of lime and magnesia as compared to a water containing all carbonates or on water of a corrosive character which might be low in hardness or of water low in hardness and high in suspended matter. In all cases the Engineer's judgment and experience must also be utilized. The figure is the best measuring stick of general conditions that we have been able to obtain up to the present time.

It is unquestioned that the removal of scale forming solids from the water has been an important factor in accomplishing the long runs of locomotives, which practice is now in general use. This has eliminated many of the outlying terminals and accomplished marked reduction in operating expenditures. It is also a fact that extended boiler washings as practiced on many roads today are also impossible without some form of treatment being used to neutralize hard water. The extended washouts have

also contributed a marked saving in operation. For these reasons it is felt that in spite of the reduced wages paid to the men now maintaining boilers as well as the reduced price of boiler material, that in view of the above tangible savings effected by the railroads during the past five years, the figure of 13 cents per pound for scale removed is conservative for estimating purposes.

Appendix C

(4) METHODS FOR REPORTING ANNUAL SUMMARY WATER STATION AND TREATING PLANT OPERATION

E. M. Grime, Chairman, Sub-Committee; W. R. Anthony, C. R. Knowles, P. M. LaBach, A. B. Pierce, W. B. Nissly, O. T. Rees, J. A. Russell, H. E. Silcox, J. B. Wesley.

In the early days of railway operation water supply facilities were of the most primitive character, ranging from hand-operated arrangement or other devices by which the locomotive syphoned the necessary water into the tender from the adjacent reservoir or creek near the track, to steam pumping units at the more important places where there was sufficient demand to justify the employment of a regular attendant. Perhaps no feature of railway operation has experienced more of a change than has this detail of water production, and on most lines today practically every one of the original stations has been replaced by something of improved design. The changes made have corresponded with the development of small power units, particularly of the fuel-oil type, as well as the use of electrical energy as soon as that power became available at reasonable cost, and also with the development of improved pumping machinery. The improvements constantly becoming available for use in this field have justified continued investigation, study and recommendation to effect desirable economies.

In the beginning almost any water that could be used for evaporation was considered satisfactory, but with increasing power demand and improvements in locomotive design it was found that the quality of the water had a most important bearing on satisfactory operation and hence the treatment of most natural waters to render them clean and free from corrosive elements has become an important problem on most railways.

The construction and the operation of facilities to provide water ample in supply and of satisfactory quality have therefore become of sufficient importance to justify a separate department to specialize in these matters. In order that this organization may have full information as to costs of operation, make studies to reduce these costs and recommend the improvement in facilities which may be desirable, it is necessary to have a record of the performance of each pumping station unit with the cost per thousand gallons of water delivered reduced to an annual basis.

Committee XI—Records and Accounts, collaborating with this Committee has prepared such forms as seem desirable for this purpose. These appear in recent volumes of the Proceedings as revised forms 1301 and 1302 and may readily be changed in minor details to suit the requirements of a particular railway. It is recommended that these forms be used in the preparation of an annual report for the purposes as stated herein and also for the information of operating or other officers concerned.

In addition to this table of statistics it may be desirable, for a complete report, to briefly summarize the results of the year's work, compare it with the previous year, show the estimated savings due to water softening, the savings accomplished by modernization of pumping plants, and recommend improvements to be undertaken the succeeding year.

Appendix D

(5) DEVELOPMENT OF DEEP WELL PUMPING EQUIPMENT

J. P. Hanley, Chairman, Sub-Committee; B. W. DeGeer, C. H. Fox, E. M. Grime, J. R. Hickox, A. W. Johnson, C. R. Knowles, W. B. Nissly, A. B. Pierce, R. A. Tanner, A. E. Willahan.

Previous reports on certain phases of deep wells and deep well pumps were presented to this Association by the Water Service Committee in 1913 by Robert Ferriday; in 1915 by J. L. Campbell and in 1926 by H. H. Richardson. This report will review the subject and mention recent improvements in deep well equipment.

Steam Head Pumps

The steam head deep well pump of the single plunger type was the pioneer of its class and was developed between 1870 and 1875. Prior to its use, reciprocating surface pumps were used to pump water from open wells. The latter pumps were usually installed on a platform near the bottom of the wells. The yield of open wells was limited compared to their diameter and when the drilled well was introduced as a better method of tapping deeper or more productive water formations, the steam head pump became a necessary part of its equipment. This type of deep well pump was favorably used by railways between 1880 and 1900, and many are still used at stations having a limited water demand. While this pump has low efficiency it also has low maintenance cost and gives reliable operation.

This type of pump has been improved and adapted to belt and gear drive and for oil engine and other present-day forms of power.

Double Acting Cylinder Pumps

As the water demands began to exceed the capacity of the single acting pump, the double acting cylinder pump was developed. This cylinder has a capacity approximately fifty per cent greater than a single acting pump of the same plunger diameter and speed and is operated by a single line of pump rods. It has been improved and adapted to present-day forms of drive and power.

Two-Plunger Pumps

This type was developed to further increase the pumpage of water from a well without increasing the diameter of the pump plungers which were limited by the inside diameter of the well casing. It has greater pumping capacity under similar conditions of speed and plunger diameter than either the single plunger pump or the double acting cylinder. It has, however, the disadvantage of having two sets of pump rods with their additional weight and higher maintenance cost. This type of pump has been improved in recent years by an arrangement of cams or pinions which start one plunger on the pumping cycle of its stroke just before the companion plunger has finished this part of its duty and is ready to start the descending or idling stroke. This arrangement serves to keep the water in constant flow and avoids starting strains. Another recent improvement in this and other forms of deep well plunger pumps is a patented spacing ring for the plunger leathers whereby the angle of bending or cupping the leather is reduced from 90 degrees to approximately 70 degrees. This change greatly prolongs the serviceable life of the cup leathers with reduced maintenance costs, and more satisfactory operation of the pump.

The two-plunger pump has also been improved in recent years by better oiling arrangements, better balance of moving parts and more compactness. It has been adapted to gear, chain and belt drive and for motor and other forms of power.

Deep Well Turbine Pump

About 1910 the deep well turbine pump began to attract attention for irrigation projects and as its development progressed, secured favorable consideration from municipalities, railways and other users, and is now the outstanding development in the deep well pump industry. The turbine is adaptable for pumpages of from 50 gallons to 6,000 gallons per minute and for very deep installations.

One pump manufacturer is now experimenting with a deep well turbine pump which has the motor submerged below the pump in a water-tight casing. Submarine cables convey current to this motor. If this unit is successfully developed, it will mark an epoch in deep well pumping by eliminating pump rods, considerable pump housing, and permitting unlimited depth of pump setting in the well.

A deep well turbine installation exists at Etiwanda, Cal., which pumps 1800 g.p.m. against a total head of 640 feet, of which 450 feet is in the well and 190 feet above the surface. The pump operates at a speed of 960 r.p.m. and is driven by a 350 horsepower vertical motor.

Other deep pump installations may be mentioned, one being in a Colorado mine delivering water from a depth of 750 feet; one in Mexico, with 860 feet of pump setting in a shaft, and one at Monona, Iowa, delivering 318 g.p.m. against a total head of 638 feet. The first three installations are of tandem design, one group of impellers and bowls being located at the bottom of pump rods and another group near the surface of the ground. This type of turbine pump uses rubber bearings of fluted design, lubricated with water. The last mentioned installation has metallic, oil lubricated bearings and nineteen enclosed impeller stages at the bottom end of the drop pipe at a depth of 509 feet from base plate of pump to first stage.

Air Lifts

While air lift installations are not so numerous as other forms of deep well pumping, still this method has a certain well-defined field where it is superior to other forms. This is illustrated by the success of the Santa Fe System has with air lift pumping in Arizona. A paper presented before the Arizona Public Health Association at Prescott, April 16, 1929, by Assistant Engineer Davenport describing the water supply methods of that Railway is abstracted in part as follows to show an unusual instance air lift operation.

"Deep wells in the western part of Arizona are pumped in nearly all cases by air lifts. The combination of the Diesel engine and the air compressor has solved the problem of deep well supplies. Contrary to popular opinion, shared by many Engineers, the air lift is superior to the reciprocating pump in overall efficiency for lifts of 400 to 800 feet. A concrete example of this is at Pica, Arizona, where a lift of 900 feet exists from three wells varying in depth from 1546 to 1788 feet. In 1917, with two 40 horsepower Diesel engines driving reciprocating pumps in the two wells then drilled, 10,000,000 gallons of water was produced at a certain cost. In 1927 with 430 horsepower Diesel engines driving air compressors, 60,000,000 gallons of water was produced at the same total cost as for the year 1917. The reason for this great decrease in cost per thousand gallons is the almost complete absence of maintenance on the below-ground facilities of the air lift compared with frequent renewals of pumps and pump rods in displacement pumps. In shallower wells turbine pumps operated by smaller semi-Diesel engines are found most suitable."

Members of the Committee on Water Service and Sanitation replied to a questionnaire sent them asking for information on wells and deep well pumps on their respective railways. A summary of the information received follows:

Number of railways reporting	14
Number of wells in use for large water supplies	623
Diameter of well—greatest	72 inches
Diameter of well—least	2 inches
Depth of well—greatest	2750 feet
Depth of well—least	20 feet
Formation of rock	153
unconsolidated	470
Gravel walled wells	94
Deep well pumping installations	463
Air lifts	40
Single plunger pumps	195
Two plunger pumps	81
Turbine pumps	118
Miscellaneous types	29
Type of pump preferred for average conditions	Turbine

Conclusions

1. The types of deep well pumps now generally used are the single or double plunger displacement pump, the turbine pump, and the air lift.

2. Displacement pumps may be considered for pumpages of 50 gallons to 300 gallons per minute and for varying depth of pump setting. Usually this depth should not be greater than 300 feet. The pump speed should not exceed 25 revolutions per minute. Overall efficiencies of this type of pump will vary from 40 per cent to 60 per cent.

3. The turbine pump may be considered for pumpages of 50 gallons to 6,000 gallons per minute and for shallow settings to settings of 500 feet or greater depth. This pump is undergoing rapid changes in design, size, and capacity and its possibilities cannot be definitely stated at this time. Overall efficiencies of 60 per cent are obtained.

4. The air lift may be considered for a wide range or pumpages and for settings of greater depth than might be suitable for other pumps. The air lift is more suitable than other pumps for installation in crooked wells or in wells which produce considerable quantities of sediment. There must be sufficient depth of water in the well to provide adequate submergence for the air lift under all pumping conditions. Overall efficiencies vary from 25 per cent to 40 per cent. No unusual developments in air lift pumping has occurred in recent years except present-day forms of drive and power for the compressors, and the use of compound compressors for unusually deep wells.

5. The type of installation can best be determined by a careful study of all local conditions, including probable operation and maintenance charges and interest and depreciation on the investment.

Appendix E

(7) STANDARD METHODS FOR ANALYSES OF CHEMICALS USED IN WATER TREATMENT

R. M. Stimmel, Chairman, Sub-Committee; W. M. Barr, R. E. Coughlan, J. H. Davidson, B. W. DeGeer, J. H. Gibboney, E. M. Grime, P. M. LaBach, J. J. Laudig, O. T. Rees, C. P. VanGundy, J. B. Wesley, R. S. Wilson.

(I) Analysis of Soda Ash

Normal Sodium Carbonate

Reagents:

1. $N/10$—Hydrochloric acid.
2. Mythl orange indicator.

PROCEDURE

Weigh out 1.325 grams of the soda ash and transfer to a 500 cc volumetric flask partly filled with recently boiled and cooled distilled water. Dilute to the mark with carbon-dioxide free water. Mix thoroughly. Pipette out 50 cc of the solution and titrate with $N/10$ Hydrochloric Acid using methyl orange as indicator. The number of cubic centimeters of $N/10$ HCl required times 4 gives per cent of Na_2CO_3 in samples direct.

(II) Analysis of Hydrated Lime

Available Calcium Hydroxide

Reagents:

1. $N/10$ Hydrochloric Acid.
2. Sugar solution (10 per cent by weight of pure cane sugar dissolved in carbon-dioxide free water).
3. Methyl orange.

PROCEDURE

Weigh accurately a 0.926 gram sample of hydrated lime. Transfer to a 500 cc stoppered volumetric flask, partly filled with the 10 per cent sugar solution. Dilute to the mark and shake thoroughly for approximately five minutes. Let stand for one hour with flask stoppered. Pipette out 50 cubic centimeters of the supernatent solution and titrate with $N/10$ hydrochloric acid using methyl orange as indicator. The number of cubic centimeters of acid used times 4 gives the per cent of $Ca(OH)_2$ in sample of hydrated lime, direct.

Appendix F

(8) PROGRESS BEING MADE BY FEDERAL AND STATE AUTHORITIES ON REGULATIONS PERTAINING TO RAILWAY SANITATION, COLLABORATING WITH THE JOINT COMMITTEE ON RAILWAY SANITATION, A. R. A.

H. W. VanHovenberg, Chairman, Sub-Committee; W. P. Hale, L. A. Henry, H. F. King, W. B. McCaleb, A. B. Pierce.

The report of the Joint Committee on Railway Sanitation was printed and distributed in November, 1931, by the American Railway Association as Circular M&S 133.

Representatives of the Engineering and Mechanical Divisions, Medical and Surgical Section and of the U.S. Public Health Service and the Canadian Health Department, collaborated in assembling the material in this report, which is circulated for information only.

Considerable of the information presented was obtained by extensive original research by individual members of the Joint Committee, and the resulting suggestions in many instances will, if applied, lead to considerable operating economies for railroads, as well as improved sanitation.

The subjects have been presented more fully than would be necessary in suggesting standard sanitary practices, because of comparatively recent sanitary developments which have not become standardized as yet, and because they may not be well understood by railway executives and employees; hence the report is more than a recommendation; it is a pamphlet of information.

Prior to the writing of the report, the Joint Committee had the benefit of a comprehensive questionnaire covering sanitary practices and sanitary organization on 78 Class I railroads. The Joint Committee soon realized from its analysis of the answers to the questionnaire that its primary function would be to harmonize good operating practices with the regulatory demands of Federal health authorities particularly, being aware of the fact that the U.S. Public Health Service is desirous of conducting its routine business as applying to sanitation with railroad officers who have regard for the necessity for good public health and sanitary regulation, and in whose offices the Federal officers would have a positive and continuous place of contact. The Joint Committee feels that much of the economies and other advantages that are suggested in the report will be lost unless adequate provision for sanitary supervision is made by the individual railroads.

The report emphasizes the fact that the history of our railroads is indelibly linked with the advances in public health and sanitary science, and that the rapidly increasing public interest in preventative health work calls for continuous study by railroads in harmonizing the numerous Federal, state and local laws aimed at protecting the health of railway patrons and of employees, with the least hindrance to railroad operation and economy.

The report covers car water systems, car water filling pipes, water coolers, car water filters, car toilets and lavatories, car ventilation and heating, passenger car cleaning, dining car sanitation, sanitary facilities for coach yards, water hose and connections, soil cans, handling of ice, water buckets, hydrants, waste disposal, coach yard platforms, service facilities for coach yards, and handling of food in commissaries.

Each subject is treated by criterion, discussion, and type. The criterion summarizes the ideal arrangement, material, schedule of operation, and employee responsibility.

The discussion emphasizes the sanitary aspects, indicates how ideal conditions can be obtained, and calls attention to possibilities for unsanitary practices. The types suggested, by description and numerous original cuts, are felt to embody the best sanitary devices, in harmony with regulation already in force and in conformity with good operating practice.

In addition, the chapters on water coolers, car water filters, water hose and connections, and waste disposal, are elaborated on by description of tests of methods and of new appliances, in appendices. Particularly noteworthy is the change in requirements following the tests on washing car water coolers, and the adverse report as to the necessity for car water filters, and the tests on a new type of hose nozzle that can be used with all car water filling systems.

The members of the Joint Committee on Railway Sanitation representing the Water Service and Sanitation Committee of the American Railway Engineering Association, feel grateful for the privilege of rendering the service they have in behalf of the member railroads.

Appendix G

(9) SEWAGE DISPOSAL WHERE SANITARY FACILITIES ARE NOT AVAILABLE

W. P. Hale, Chairman, Sub-Committee; W. R. Anthony, R. E. Coughlan, W. L. Curtiss, L. A. Henry, R. L. Holmes, C. R. Knowles, A. W. Johnson, J. A. Russell, H. E. Silcox, D. A. Steel, H. W. Van Hovenberg, F. P. Turner, A. E. Willahan.

Your Committee considers the assignment that of presenting for guidance of the railroads the various methods of disposing of human waste where connections with sewage systems are not readily available.

The proper disposal of human waste is the greatest factor influencing the general health of any group. Where proper steps have been taken to handle such waste these groups have been spared the periodical outbreaks of typhoid fever, dysentery and other intestinal diseases. The germs of these diseases occur in nature only in the discharges from the human body or in substances contaminated with these discharges. Human beings contract such diseases only through swallowing such contaminated matter with food and drink. The problem of control is complicated by reason of many sufferers discharging these disease germs after apparent full recovery from the active stages of the disease, with the consequent danger of personal contact. These people are called disease "carriers."

Hookworm, a parasitic disease, occurs in widespread areas in the United States. Its control is readily effected by proper disposal of human waste.

The problem of sewage disposal where sanitary facilities are not available is a phase of engineering work of vital importance to the railroads, as well as to the communities at large. In the case of the railroads, with their employees distributed over many states, in cities, towns, villages, and in isolated rural points, in both large and small numbers, even singly in some cases, the problem becomes one of varied design.

The various railroad sysems traverse wide territory and they are, therefore, subject to Federal regulations, various State codes and many city and village ordinances and rules. Confusion sometimes develops in harmonizing the views of all concerned as a result of the above conditions. For these reasons, the adoption of system standards of practices are matters which present many complications, and no such standards, therefore, are recommended for the present.

Railroad systems experience a wide variety of waste disposal problems ranging from the operation of a sewage system in isolated shop areas to the toilet facilities for rural section houses, and from the sanitary control of human wastes from large moving extra gangs or groups of patrons to the terminal care of toilet wastes from the single business car.

The object of this report, then, is to assemble briefly the information available applying to this phase of sewage disposal under the following headings:

(1) Federal Regulations and State Codes Affecting Interstate Carriers
(2) Choice of Methods
(3) Typical Applications

1. Federal Regulations and State Codes

The Standard Railway Sanitary Code, promulgated by the U.S. Treasury Department, Bureau of Public Health Service, has been adopted by 41 of the 48 states. This code prescribes minimum requirements for railroad toilet facilities for both employees and patrons, and state regulatory bodies exercise considerable inspection supervision of these facilities. Copies of this code, which is published by each of the states in a separate pamphlet for distribution and which is available to every railroad sanitary officer gives in detail each item regarding sanitary regulations and same will not be given in this paper.

2. Choice of Methods

The varied problems of waste disposal may be considered as follows:

(A) Large Groups of Employees or Patrons
- Terminals with dwellings and offices
- Permanent camps (rock quarries, ballast pits, etc.)
- Mobile labor camps (extra gangs, bridge and building gangs, paint gangs, etc.)

(B) Small Groups of Employees or Partons
- Stations
- Section houses, bridge watchmen's houses, etc.
- Mobile labor camps (fence gangs, water service gangs, etc.)

Depending on the numbers involved and the means of disposing of fecal matter, permanent locations may be chosen as follows:

- Water carriage and disposal by dilution or treatment
- Septic tank or cesspool with or without disposal by dilution or treatment
- Chemical or septic toilets
- Privies

For mobile units there is the choice of

- Chemical toilet installations
- Portable wood privies
- Portable seat box with collapsible shelter walls

Water Carriage and Disposal by Dilution or Treatment

The most highly developed and at the same time the most expensive of the means of disposing of fecal matter is by water carriage and disposal by means of dilution or treatment. Where railway terminals or stations having water under pressure require such elaborate sewage systems, all plans should be prepared or reviewed by a competent sanitary engineer conversant with state codes, local requirements and conditions. Such systems will approximate the modern sewage systems for small towns or cities, and plans must be approved by the State Sanitary Engineer in the state in which system is planned.

Septic Tanks or Cesspools, and Disposal by Dilution or Treatment

Although much has been written concerning sanitary sewers and septic tanks, there are many people who have only a hazy idea of the subject or else a wrong impression as to what a septic tank really is.

First of all, it should be clearly understood that the ordinary septic tank does not purify sewage, but merely prepares the sewage for final disposal by means of irrigation systems or filters. The purpose of the tank is to separate and hold the solid particles which will settle to the bottom or float to the surface in order that the liquid which reaches the outlet will be clear, or nearly so. The sewage as it leaves the tank may and usually does, contain more bacteria than it does when it enters. Although it may be as clear as spring water, it is far from pure and will cause bad odors if allowed to stand in an open ditch. Hence, the septic tank is only the first step in the disposal process.

The deposit which collects in the bottom of the tank is spoken of as "sludge." The particles which float to the surface form a "scum" or "mat." Fortunately most of the "sludge" and "scum" is changed into liquids and gases by a natural fermentation process, which goes on continuously in a septic tank. Otherwise the tank would soon fill up with solid matter. If the tank is large enough it may not need cleaning for several years. On the other hand, if the tank is not large enough, not enough time is given for the fermenting bacteria to do their work and it will need cleaning often. Experience seems to show that for average conditions, the tank should be made of a size to hold at least fifty gallons per person.

The liquid effluent from a septic tank is usually disposed of through a tile irrigation system. The liquid is taken off the top of the septic tank chamber in such a way that the outlet is water-sealed at all times. The number of feet of drain tile for an irrigation system depends first on the nature of the soil, and second, on the daily amount of sewage to be cared for. A dry, sandy soil will absorb more sewage than a heavy soil such as clay. When the soil is clay, it is best to dig deeper tile trenches and backfill partly with cinders or sand before laying the tile. Often a single tile line is sufficient for the purification field. Where the plot of ground is not sufficient it may be necessary to spread the sewage by means of a distributing box and several lines of open-joint tile running therefrom. A test hole should be dug to observe the rate of absorption before the installation of a tank with an absorption tile system. For the typical installation 50 feet of tile per person will ordinarily suffice. Where there is light porous soil, 30 feet of tile per person will suffice. In tight soils which absorb sewage slowly as much as 100 feet per person may be needed.

The location of the septic tank and the purification tile system must be selected with care. Although septic tanks, as a rule, do not cause complaints on account of odors, nevertheless, the tank should be located as far away from buildings as practicable, and never closer than 100 feet from a well, spring or cistern.

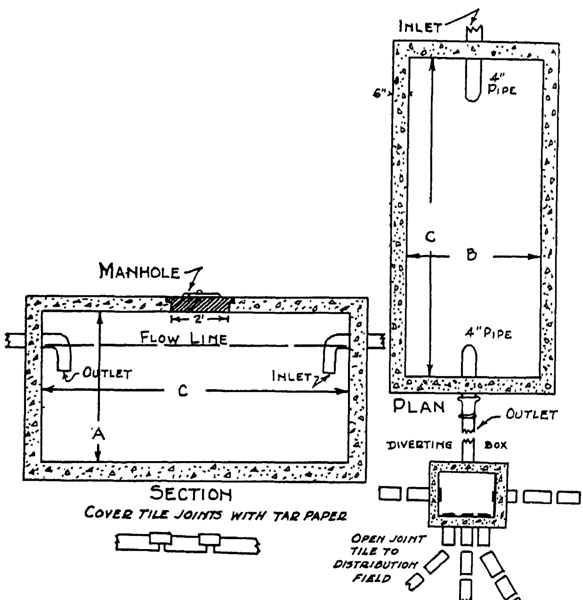
The layout shown in the illustration will provide a satisfactory method of sewage disposal. It is simply a sanitary sewer system in miniature. (See Figure 1.)

Chemical Toilet

The chemical toilet, like the septic toilet, has as its object the liquefaction of fecal matter so that it may be the more easily disposed of. This object, however, is accomplished through chemical instead of bacterial action. Generally, a special iron tank of sufficient size to allow for storage over a considerable period of time, six months to a year, is provided. The tank is then charged with a certain stated amount of caustic

substance which has the power of liquefying fecal matter. When the tank is filled to its capacity the liquefied matter is removed, and the tank recharged.

Like the septic toilet, the chemical toilet has the advantage of adaptability to any location. It also makes ultimate disposal of the effluent easy by means of liquefaction. In addition to liquefaction, there is a high degree of purification accomplished through the partial destruction of bacteria and the eggs of intestinal parasites. The chemical toilet has a virtue greater in extent than any other type, that of deodorization. It is well-suited to indoor installation, and can be placed in station buildings proper where it will be easily accessible to patrons and employees alike, and where proper control of its use and maintenance can be governed by the agent.



STANDARD DIMENSIONS

NUMBER OF USERS	A (DEPTH)	B (WIDTH)	C (LENGTH)
0-10	4.0 FT.	4.0 FT.	6.5 FT.
10-25	5.0 FT.	5.0 FT.	10.0 FT.
25-50	7.0 FT.	6.0 FT.	12.0 FT.

FIG. 1—SEPTIC TANK.

The bowl or bowls may be placed indoors at convenient locations and connected to the tank with necessary connecting tubes. The tank must be directly underneath the toilets to avoid the use of flushing water. In installing such toilets, provision must be made for readily cleaning the tank. All joints between the bowls and tank must be watertight. The installation must be made so as to insure the tank protection against frost. The ventilating pipe, necessarily, in such installations must be properly installed and maintained.

Drainage may be provided by tile or leaching well. When tile drainage is used, sufficient lengths of abutted joint tile lines should be provided to receive and readily

dispose of the entire tank volume. Whenever the leaching well is used, a capacity equal at least to the capacity of the tank should be provided with a drain leading thereto from the tank. The construction of the cesspool or leaching well and its distance from the tank must be made according to conditions that prevail in the case and in accordance with requirements as suggested above.

One disadvantage of the chemical toilet is that it is generally a commercial production. The life of the tank is not permanent, the cost of maintenance is high, and this type of installation requires constant supervision.

Septic Toilets

A septic toilet consists of toilet bowl directly connected to a septic tank by proper tube, the whole being operated as a dry system. Septic toilets should not be confused with septic tanks, for while the action is similar in both cases, the practical operation is essentially different. The most essential difference lies in the fact that the septic tank receives an abundance of water automatically through flushing, while the septic toilet receives none except that which is added at such intervals and in such amounts as the user sees fit.

The first cost of the septic toilet is large and intelligent care is required in operation. Water must be added regularly in order to maintain a constant water level. For these reasons the septic toilet is not as a rule suitable for use on the railroad where the public and large groups of employees are involved in the use of same.

Pit Privies

As noted in the Standard Railway Code, the sanitary privy for station, section house, or construction camp (not on wheels), should be of a design approved by the State Department of Health. In the majority of cases, such a privy will be found to be the most economical, and when properly constructed and maintained, a satisfactory method. The following requirements for a sanitary privy sufficient to merit approval by the State Board of Health are suggested:

The essential requirements are a pit and a fly-tight seat or riser, close-fitting seat covers, and the sealing of joints between house and pit. The pit should be located at proper distance from existing well, spring or cistern used as a potable water supply and so placed that the surface and underground drainage will be away from such well, spring or cistern. The pit should not be placed over limestone ledge, slate or other formation where cracks or crevices lie close to the ground surface. The pit should have ample capacity for the use intended and care must be exercised and provision made against collapse of pit walls. In low, marshy ground, subject to flooding, it may be desirable to provide a concrete pit.

The pit should be about 5 feet in depth, about 3 feet in width from front to back, and length from side to side will vary with the number of seat holes, but should be 18 inches less than the length of the privy house. Excavated dirt from the pit should be banked up around the pit at least six inches above the original ground level and tamped in place around the walls of the privy building.

The privy house must be substantially built. The floor and entire seat box should be made of good stock and afford ample seating capacity. Seat covers (lids) should overlap all sides of the hole at least 3 inches and provision should be made by use of spring hinges or otherwise to cause the seat lid to close automatically when the seat is not occupied. A block may be nailed inside the back wall so as to cause the lid to fall of its own accord. It is desirable for the roof to extend at least one foot beyond the walls of the house and it should be watertight. Care should be taken so that the house will rest firmly over the pit and dirt be banked up around the house on all sides of the

pit as noted previously. Flash boards over the ground at rear of the house will divert rain and surface water from the pit.

A vent pipe not less than three inches in diameter or four inches square should be provided for each seat hole, and may be of metal or wood. Such vent pipe should be screened with 16-mesh wire. Vent pipe should extend from a point just below the seat to at least two feet above the privy house roof.

In some cases, it may be desirable, from an aesthetic standpoint, to provide concrete floor. The above specifications will also apply to such construction.

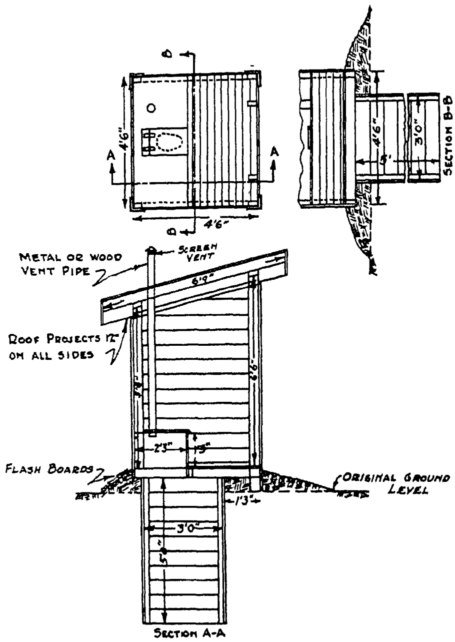


FIG. 2—SANITARY PIT PRIVY—WOOD CONSTRUCTION.

NOTE.—General plan and dimensions of house may be changed to conform with railroad's standard so long as required pit, vent and seat lids are provided.

As noted previously, where privy is located in marshy ground or near limestone or slate formations, or where the location is deemed permanent, it may be desirable to provide a concrete pit. The general construction of such a concrete vault privy is the same as for wood construction except for the vault, plan for which is suggested in Fig. 3.

Mobile Units

The sanitary requirements for portable seat boxes with collapsible shelter walls are similar to those given for privy houses. The former are constructed in such position that they can be quickly and economically knocked down and re-erected. In some cases temporary pits are provided and in effect is a temporary pit privy. Portable seat boxes are similar to above except that shelter walls are absent. Their use is restricted and for obvious reasons they are not recommended. Chemical toilets are essentially the same as for permanent units except that the tanks are of smaller capacity and are not buried. The patrolling of set-ups in mobile service is important, both during the use and upon dismantling. All excrement should be disposed of in a sanitary manner, all pits, etc.,

being properly treated with sufficient alkali and well backfilled. Care should be taken to prevent contamination of water courses, cisterns and wells.

3. Typical Applications

At Milwaukee, Wis., the Chicago, Milwaukee, St. Paul & Pacific Railway was confronted with the problem of sanitary disposal of sewage from bunk cars occupied by 180 laborers. This crew was stationed in the Milwaukee Railway yards and the Sanitation Board of Milwaukee demanded that sanitary means be devised for disposal of resulting sewage. An arrangement as shown in Figs. 4 and 5 was finally decided upon.

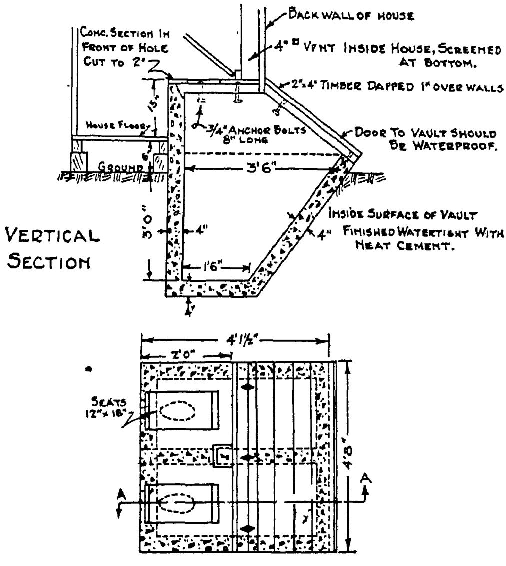


Fig. 3—Double Compartment Concrete Vault Shown in Sections.

The installation consists of four tanks installed under the freight car, two on each side of the car as shown in the picture. Connected with these tanks are three tubes per tank and the bowls as shown connecting to the tubes. Besides the bowls are agitators which are worked up and down to stir the sewage and chemical together and render them liquid. Each bowl has a vent pipe connecting into a larger vent pipe which projects out of the top of the car.

When the tanks are full, they are emptied by moving the car to a convenient place, where a hole is dug under the tanks, the contents dumped into the hole and then the hole is filled with earth. When the train is outside the yard so it can be moved to the country to some spot where no harm is done by emptying, that is done.

The cost of the installation, so far as the actual labor is concerned, was very little. The time of three men was required for two days to cut holes in the car and fasten the tanks in place with iron bands strongly braced to hold them in place, set the bowls, and run the vent pipes.

The actual cost of the installation depends upon the type of equipment purchased. In this case, the tanks were specially made, 24 inches by 24 inches by 72 inches, of 14-gage copper-bearing steel. These tanks could be made of 12-gage or 10-gage if desired. The actual cost of the equipment ran close to $600.00.

According to officials of the Milwaukee Road, the installation has proven to be the best solution of the particular problem that they can devise and is believed to be the most economical also.

FIG. 4—VIEW SHOWING VENTILATORS AND TANKS.

FIG. 5—VIEW SHOWING INSIDE OF "MILWAUKEE" FREIGHT CAR.

REPORT OF COMMITTEE XXII—ECONOMICS OF RAILWAY LABOR

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J. J. Baxter,
W. R. Bennett,
T. S. Bond,
A. E. Botts,
H. A. Cassil,
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F. S. Schwinn,
William Shea,
L. C. Stahl,
H. M. Stout,
H. R. Westcott,
C. R. Wright,
Committee.

To the American Railway Engineering Association:

Your Committee presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A). No revisions are recommended, except that submitted under subject 9.

(2) Analysis of operations of railways that have made marked progress in the reduction of labor required in maintenance of way work (Appendix B).

(3) Effects of recent developments in maintenance of way practices on gang organization (such as use of heavier rail, treated ties, and labor saving devices, which make practicable small section forces, and conducting the major part with extra gangs) collaborating with Committees I—Roadway, II—Ballast, III—Ties, IV—Rail, V—Track and XVII—Wood Preservation (Appendix C).

Recommended that the report be received as information.

(4) Standard methods for performing maintenance of way work for the purpose of establishing units of measure of work performed (Appendix D).

(5) Programming of bridge and building work, collaborating with Committees VI—Buildings, VII—Wooden Bridges and Trestles, X—Signals and Interlocking, XV—Iron and Steel Structures and XXIII—Shops and Locomotive Terminals (Appendix E).

Recommended that the report be received as information.

(6) Revised plans for outfit cars for maintenance of way department employees, collaborating with Division V—Mechanical A.R.A. (Appendix F).

Recommended that the report be received as information.

(7) Economics of methods of weed killing (Appendix G).

(8) Use of motor trucks in maintenance of way and structure work (Appendix H).

Recommended that the report be received as information.

(9) Gang organization and methods of performing the more common tasks of maintenance of way work, including the revision of the time studies now in the Manual to bring them in accord with modern mechanical methods (Appendix I).

Recommended that the report be received as information.

Respectfully submitted,

The Committee on Economics of Railway Labor,

F. M. Thomson, *Chairman.*

Bulletin 349, September, 1932.

Appendix A

(1) REVISION OF MANUAL

John Evans, Chairman, Sub-Committee; A. E. Botts, H. A. Cassil, H. I. Hoag, G. M. Magee, J. A. Parant, J. C. Patterson, H. M. Stout.

No revision of the Manual is recommended, except recommendations submitted under subject 9, "Gang Organization and methods of performing maintenance-of-way work, including revision of time studies now in the Manual".

Appendix B

(2) ANALYSIS OF OPERATIONS OF RAILWAYS THAT HAVE MADE MARKED PROGRESS IN THE REDUCTION OF LABOR REQUIRED IN MAINTENANCE-OF-WAY WORK

J. A. Parant, Chairman, Sub-Committee; T. S. Bond, J. A. Gorr, H. I. Hoag, C. H. R. Howe, E. T. Howson, J. H. Kelly, C. R. Knowles, G. E. Lowe, G. M. O'Rourke, J. C. Patterson.

The Committee reports progress for the work of this assignment during the current year.

Appendix C

(3) EFFECTS OF RECENT DEVELOPMENTS IN MAINTENANCE OF WAY PRACTICES ON GANG ORGANIZATION (SUCH AS USE OF HEAVIER RAIL, TREATED TIES AND LABOR-SAVING DEVICES, WHICH MAKE PRACTICABLE SMALL SECTION FORCES, AND CONDUCTING THE MAJOR PART OF MAINTENANCE WORK WITH EXTRA GANGS)

F. S. Schwinn, Chairman, Sub-Committee; J. J. Baxter, W. R. Bennett, J. F. Dobson, John Evans, H. H. Harsh, J. H. Kelly, G. M. O'Rourke, E. L. Potarf, H. M. Stout.

Previous reports of this Sub-Committee as printed on pages 194 to 197, inclusive, Vol. 32, and pages 385 to 390, inclusive, Vol. 33, Proceedings, have covered the subject "Effects of Recent Developments in Maintenance of Way Practices on Gang Organization" in considerable detail coupled with certain definite conclusions. In the report printed in Vol. 33, complete descriptions of the practices in effect on five railways were outlined.

The present report supplements the information previously given for these five railways and also includes a resumé of the practices of four additional railways. The outlines of the organizations and practices as adopted by these railways after extensive experimentation approximately cover the several variations which have been generally followed and which were found to give the most satisfactory results.

Chicago, Milwaukee, St. Paul and Pacific Railroad

The report of this railway is given on page 386, Vol. 33. No changes are reported in gang organization as previously described.

The Pennsylvania Railroad

The report for this railway is given on page 387, Vol. 33. The organization plan outlined in this report has been extended over additional territory. The heavier main-

tenance work is done by gangs of sufficient size to properly perform such work, permitting a further reduction in the number with resulting increase in the length of sections. During the period January, 1931, to March, 1932, this railway eliminated 331 sections.

Great Northern Railway

The report for this railway is given on page 388, Vol. 33. The latest advice is to the effect that the trackmen are very enthusiastic about the form of organization now in use, the claim being universally made that more and better work can be accomplished than was possible under the old organization.

Boston & Maine Railroad

The report for this railway is given on page 388, Vol. 33. This railway has extended its plan for branch line maintenance from 24 miles in 1930 to 115 miles in 1931 and to 326 miles in 1932 with proportional resulting economies. The opinion is expressed that the severe climatic conditions of northern New England have furnished a very full test of the value of the new plan of organization and that it has completely justified itself.

Missouri Pacific Lines in Texas and Louisiana

The report for this railway is given on page 389, Vol. 33. The plan of gang organization developed during the past two years has been extended to cover all lines. All light traffic branch lines are maintained by floating section gangs, each of which is assigned from 20 to 50 miles. A further decrease in the number and increase in the length of sections has been accomplished; since 1928 the number of sections has been decreased from 345 to 209, or 39.4 per cent, and the average length increased from 8.0 miles to 13.2 miles of main track.

Information with regard to additional railways not previously reported follows:

Chicago, Burlington & Quincy Railroad

As the result of improved rail, tie, ballast and drainage conditions and the use of labor-saving devices, this railway has been able to introduce a complete reorganization of its track maintenance forces. Under the new plan, the section gang continues as the primary unit in the maintenance organization, but the average length of sections was increased from about 8 miles to 12 miles, thus accomplishing a reduction of one-third in the number of sections.

The section foremen, however, are relieved of the duty of daily track patrol, this function being performed by track supervisors (a new position) each of whom has jurisdiction over about six sections, or 75 miles, and who report to and work under the direction of the Roadmaster. This plan has also permitted increasing the length of Roadmasters' territories from one engine district to two engine districts, or about 225 miles, this generally covering three Supervisors' territories.

The plan was applied progressively, one operating division being covered at a time. By the close of 1931 the new plan was in effect on all lines west of the Missouri River and a part of the lines east, and the results were so favorable that it was expected to continue the reorganization through 1932 to include the entire system. The plan has permitted increasing the number of men per section and by improved supervision, has eliminated to a large extent what would normally be unproductive time. The results up to date have been very satisfactory and apparently are accompanied by appreciable economies. A full account of the Burlington plan may be found in the January 1932 isesue of Railway Engineering and Maintenance.

Delaware, Lackawanna & Western Railroad

During the early part of this year, this railway reorganized its track maintenance forces between Hoboken and Buffalo. Section lengths were increased to 12 miles of main track or 6 miles of double track, the section gangs consisting of a foreman with six laborers during the summer or working season and three to four laborers during the winter. Only ordinary maintenance such as smoothing track, tightening bolts, caring for right-of-way and other minor work is performed by the section gangs.

District gangs consisting of a foreman, gang leader and twenty-five men are assigned during the working season to approximately every 48 miles or four sections. To these

gangs are assigned all work in connection with raising track, general surfacing and lining, tie renewals and similar heavy duties. These gangs are equipped with 12 tool tamping machines and are expected to cover about one-fourth of their territories each year. During the winter they are to be reduced to a minimum or entirely eliminated as requirements may justify. As this plan of organization has been in effect less than one year, sufficient data covering results are not now available.

Erie Railroad

Prior to the present year, program track work on this railway, with the exception of full ballast and large reballast jobs, was handled by section gangs temporarily enlarged or by bunching several sections gangs. Under the new organization, such work is all handled by extra gangs working throughout the summer season (April to October) and section gangs handle only the ordinary section work such as light tie renewals and adjustment maintenance. Outside of the working season, the section gangs are reduced generally to a foreman and two men per main line section and a foreman and one man on branch line sections.

The full ballast gangs consist of 75 men, reballast gangs have about 60 men and gangs engaged in tie tamper work vary from 11 to 38 men, depending upon the size of the tamping machines used. These extra gangs are employed throughout the working season and are usually laid off during the winter. Rail laying is handled in short stretches of one or two miles by utilizing a reballast gang, and this gang performs the follow-up work immediately after laying the rail. All of these gangs are equipped with necessary labor-saving devices and may be considered as well trained specialized gangs with a carefully balanced organization.

The present plan of track organization has resulted in extensive economies in track maintenance due to improved efficiency and to the elimination, as far as possible, of nonproductive time. As an example, a comparison of tie tamper work handled this year with that of 1931 indicates a system average increase of 68 per cent in performance. The operation of the new organization has been entirely satisfactory.

Lehigh Valley Railroad

This railway has accomplished marked economies in track maintenance since 1928. During this period the number of sections has been reduced from 302 to 160, or nearly one-half, with an average outlying double track section including nine miles of double track. The economies effected have been the direct result of improved and heavier track materials, better roadbed condition and the use of labor-saving equipment, and such economies are reflected in an appreciable reduction in section and extra gang man-hours as well as in improved track conditions.

Track surfacing is performed by specialized gangs during the summer months and all rail, insofar as possible, is laid after the season of surfacing track, or during November and December. The rail laying is performed by bunched section gangs with the view of giving continuous work during the winter. A full account of the practices of this railway may be found in the June 4, 1932, issue of Railway Age.

Recommendations

The Committee recommends that this report be received as information.

Appendix D

(4) STANDARD METHODS FOR PERFORMING MAINTENANCE-OF-WAY WORK FOR THE PURPOSE OF ESTABLISHING UNITS OF MEASURE OF WORK PERFORMED

Lem Adams, Chairman, Sub-Committee; W. R. Bennett, A. E. Botts, Paul Hamilton, C. H. R. Howe, G. M. Magee, J. A. Parant, H. E. Perkins, E. L. Potarf, L. C. Stahl.

The above subject was originally assigned to this Committee in 1920 and was studied each year until 1926.

The first report on this subject was presented in 1922, when the Association adopted for publication in the Manual a plan for standardizing the performance of various units of maintenance of way work for the purpose of establishing units of measure of work performed.

The 1923 report (page 287, Vol. 24) outlined information obtained through requiring section foremen on one of the large railways to keep records of work performed each day, and from this study forms were prepared which it was recommended be used to obtain further data.

In 1924 report (page 788, Vol. 25), a comprehensive tabulation of man-hour performances was prepared for the major items of maintenance of way work, particularly rail laying and tie and ballast renewals.

In 1925 (page 930, Vol. 26) the report of the Committee contained a discussion of the main features of the plan previously recommended, which were as follows:

1. Standard methods and time schedules for each item of work.
2. Instructions to foremen to enable them to submit accurate reports of performance.
3. Closer supervision by means of planning and dispatching the work in advance.
4. Sample forms for the notation of records and performance for comparison of results.

It is the opinion of the present Committee that the two outstanding features to be considered are "Standard methods and time schedules for each item of work" and "Closer supervision by means of planning and dispatching the work in advance".

In meeting the conditions now confronting the railways it has been found that we can greatly curtail or dispense with many of the operations formerly considered essential in performing maintenance of way work. However, the time schedule still remains an important item, since without definite schedules, we will work with "hit-and-miss" methods that are not conducive to economy. Likewise, planning and dispatching are essential if we are to secure maximum efficiency, as any haphazard method of performing work, even on a small sub-division, will result in important items of work being delayed or omitted from the program.

It has been found that excellent results can be obtained from section forces by having all forces on a supervisor's district perform the same task on a given day. This, of course, requires a very close knowledge of conditions by the supervisor, but greatly reduces the time consumed in the operation.

In the bridge and building department scheduling is equally important, as these forces can consume a great deal of time in making miscellaneous repairs that may come to their attention in working over an assigned territory, and not be able to accomplish the more essential work on their schedule. The most important items in this class at this time are bridge repairs, and when these have been definitely scheduled as to the time to be done and man-hours to be consumed there is no guess-work as to the forces required to accomplish them.

Various reports of this Committee in the past have set up a table of equated track values, which is very useful in the establishment of section limits, and for ready reference the table of equation is again repeated:

One mile of first main track equivalent to:

1.15 miles of second main track
1.33 miles of third or fourth main track
2.00 miles of branch line track
2.00 miles of passing and throughfare track
3.33 miles of yard tracks
12 main line switches
20 sidetrack switches
10 railroad crossings
12 city street crossings
25 to 50 country road crossings
½ mile of track pans
4 miles of ditches

In applying these values, due consideration must necessarily be given the volume of traffic and the varying conditions of the track involved. Traffic density is, of course, the destructive agent on any piece of track, and the condition of the rail, ties, and ballast are important factors that must be considered at all times in the assignment of track forces.

In the 1924 report of this Committee the following conclusions appeared:

(1) The making of time studies and the comparison of performance of an individual gang with a standard, increases the efficiency of the gang under observation and of other gangs which are made acquainted with results.

(2) The general use of standard methods and units of measure of performance on divisions and districts of a railway has resulted in increasing the efficiency of track forces.

The Committee's final report in 1926 concluded that:

"It is not possible to determine a fixed unit of cost of maintenance of way and structures accounts for any unit of property, such as the equated mile, or for any unit of use, such as thousand car miles. It is further the conclusion that it will be impossible to determine upon such unit of cost at any future time unless all railways were to adopt the use of standard materials and standard practices, and even then there would exist differences reflecting the differences in location, climatic conditions and physical construction."

Your Committee concurs in the above conclusion at this time.

Appendix E

(5) PROGRAMMING OF BRIDGE AND BUILDING WORK

A. E. Botts, Chairman, Sub-Committee; Lem Adams, H. A. Cassil, J. F. Dobson, J. A. Gorr, E. T. Howson, H. E. Perkins, D. M. Rankin, F. R. Rex, William Shea, H. R. Westcott.

Important data and information as to the practices in effect on various railways has been collected on this subject on the programming of B&B work.

A recommended method, with necessary forms, for programming bridge and building work is being worked out in detail, but is not yet in shape for presentation in its final form to the Association, consequently the Committee for this year reports progress.

Appendix F

(6) REVISED PLANS FOR OUTFIT CARS FOR MAINTENANCE-OF-WAY DEPARTMENT EMPLOYEES

G. M. Magee, Chairman, Sub-Committee; J. J. Baxter, T. S. Bond, H. I. Hoag, G. E. Lowe, D. M. Rankin, F. R. Rex, William Shea, L. C. Stahl, C. R. Wright.

Considerable work has been completed by the Sub-Committee on this assignment during the current year, but it was thought best to withhold plans until all were available for publication at one time. In view of this, the Committee reports progress only.

Appendix G

(7) ECONOMICS OF METHODS OF WEED KILLING

H. H. Harsh, Chairman, Sub-Committee; H. A. Cassil, J. A. Gorr, C. R. Knowles, D. M. Rankin, F. R. Rex, F. S. Schwinn, L. C. Stahl, C. R. Wright.

The Committee reports progress only for the current year and recommends the subject be continued for further study.

Appendix H

(8) USE OF MOTOR TRUCKS IN MAINTENACE-OF-WAY AND STRUCTURES WORK

H. M. Stout, Chairman, Sub-Committee; T. S. Bond, A. E. Botts, John Evans, H. H. Harsh, C. R. Knowles, G. E. Lowe, H. E. Perkins, F. R. Rex, William Shea, H. R. Westcott.

In the constant search for more economic methods being carried on by American railways, the use of motor trucks in maintenance of way and structures work is a recent innovation. The extent to which railways have availed themselves of the services of such equipment as auxiliary to or in the replacement of track motor cars, work trains and other means of transportation, is as yet limited and comparative costs cannot be set up.

As a basis for the study of this subject your Committee has secured a very comprehensive—practically complete—survey of the railways of the United States and Canada, including trunk lines, short lines and terminal companies, determining the character of service and extent automobile and trucks have been utilized in engineering and maintenance of way and structure work. The tabulation below includes only those railways which have utilized such equipment in engineering and maintenance work.

Railroad	*No. of Truck*	*Capacity*	*Remarks*
A. C. L. R. R.	2	2 & 5 ton	
A. T. & S. F. Ry.	3	1½ to 3½ ton	Also 9 passenger cars
B. & O. R. R.	2	¼ to 3 ton	
B. & A. R. R.	1	2 ton	
B. & M. R. R.	10	1 to 3 ton	
C. R. R. of N. J.	1	3 ton	
C. & O. R. R.	2	1 & 1½ ton	Also 5 passenger cars
C. & N. W. Ry.	5	2½ ton	" 1 " car
C. B. & Q. R. R.	1	1½ ton	
Chgo. So. Shore	6	¾ to 2 ton	Also 1 passenger car

Railroad	No. of Truck	Capacity	Remarks
C. R. I. & P. Ry.	2		Also 12 passenger cars
C. C. C. & St. L.	2	1 ton	" 12 " "
Can. Pac. Ry.	2	1½ ton	
D. L. & W. R. R.	16		Also 2 passenger cars
Detroit Term's.	2	1 to 3 ton	
E. J. & E. Ry.	4	¾ and 3½ ton	
Erie R. R.	13	½ ton	
G. N. Ry.	16	1 to 5 ton	Also 26 passenger cars
Gulf Coast Lines	2	1½ ton	
Ill. Cent. R. R.	15	1 to 3 ton	
Ill. Term. R. R.	2	1 ton	
L. & N. E. R. R.	2		Also 1 passenger car
M. K. & T. Lines	1	2 ton	
M. P. R. R.	6		Also 7 passenger cars
N. Y. C. & St. L.	1		
N. Y. O. & W. Ry.	1	1 ton	
N. P. Ry. Co.	8	1 to 2½ ton	Also 2 passenger cars
Pere Marquette	1	½ ton	
N. Y. N. H. & H. R. R.	43	½ to 3 ton	Also 4 passenger cars
Pac. Elec. Ry.	18	½ to 4 ton	" 3 " "
Reading R. R.	4	1 to 1½ ton	
St. L. & S. F. Ry.	2	20-pass. busses	
Seabord Air Line	2	1 ton	
Southern Pac. Co.	36	¼ to 3½ ton	
T. & P. Ry. Co.	3		Also 3 passenger cars

While quite a number of railways have had successful experience with the use of trucks, other railways have decided there was no particular advantage or benefit to them in their use.

The economy in the use of this type of equipment seems to be largely dependent upon geographic location and traffic and, to a certain extent, local conditions. Under favorable conditions there appear to be very definite advantages and economies in the use of motor trucks.

The conditions which appear favorable to auxiliary motor truck operation in maintenance are:

1. In and around terminals where traffic congestion results in frequent and long delays in the transportation of crews and materials by motor or hand car.
2. When fixed property is located at some distance from tracks and therefore inaccessible by train or motor car service.
3. Around junction points where lines converge at small angles or on paralleling lines where relatively short cross-country trips enable one crew to cover territory on more than one line.
4. Lines which have paralleling highways when maintenance crews can cover more mileage than could be covered with rail motor car.

The use of motor trucks is of course not feasible for all of the various branches of railway maintenance. It is, however, practical in connection with certain phases of bridge and building work; water service; paint gangs; such forms of signal maintenance as the maintenance of highway crossing signals, flashers, etc.; telegraph and telephone maintenance; disposal of snow and other forms of storm débris; and for transport of survey and engineering crews, particularly when conditions obtain as stated above.

The modern automobile and truck under normal conditions are reliable, operate at a high degree of safety, and are free from the delays incident to awaiting the approach and passing of trains to which the motor car is subject. These are important factors in the economy which may be realized in their operation. Also the flexibility, versatility

and comfort are other advantages which have been noted by carriers which have employed them in maintenance and engineering work.

Illustrative of the wide range and scope of the work to which the motor trucks have been employed in railway maintenance and engineering service, the following detailed descriptions are given. These data have been compiled from the returns to a special questionnaire sent to railways known to have used motor trucks, special correspondence, and other sources of information.

Baltimore & Ohio Railroad

This road made a careful study in 1931 of its maintenance problems especially in connection with automatic block signals, train order and highway signals, gates and bells, on the Akron Division. The force engaged in their maintenance consisted of 11 maintainers, 4 assistant maintainers and 5 helpers. These forces theretofore had used trains and gas cars for transportation and in several instances, due partly to curtailment in train service, several maintainers were using street cars and buses, resulting in expense accounts for such men. The existing arrangement also necessitated nine men working alone, which was considered a handicap.

A plan was developed which, by redistributing the territory and adding three small trucks, would result in a direct saving of $2126.60 per year. The greatest advantage, however, was the improved maintenance and the reduction in the number of men working alone to five.

Boston & Maine Railroad

This road commenced the use of motor trucks in June, 1927. Ten one-ton trucks were placed in paint spray service, two 1½-ton trucks for track supervisors' use and one three-ton truck for bridge and building work. Their use resulted in the reduction of non-productive time by facilitating the movement of men, material and equipment. The road plans on replacing four of their trucks with new units.

Erie Railroad

The first motor truck in maintenance of way was placed in service in March, 1928. They now have in use 13 trucks of 1½ tons capacity. Three were added during the past year. Additional units are to be programmed as occasion develops. The equipment is used by survey corps, plumbing, carpenter, motor car repair and signal gangs and for distribution of store department materials at terminals. Saving of approximately $1000 for each car per year is claimed.

Great Northern Railway

This road has within the past few years placed a considerable number of motor trucks in operation. The equipment has been assigned to various departments for operation. Fifteen trucks ranging in size from one to five tons capacity were assigned to maintenance service. Such equipment, while assigned to various departments for operation, is, however, not used exclusively by that one department, but is used for any service for which it is suitable in the locality where it is located. Trucks have been found particularly economical in B&B maintenance around terminals and docks, hauling both men and material to the site of work. In the ore mining district where considerable shifting of tracks is necessary, motor trucks have been found economical in the transportation of men and material. It is roughly estimated that the motor trucks save their cost each year.

Northern Pacific Railway

The use of automobiles on this railway was first commenced in about 1912 in connection with railway location work. The machines at that time were hired for special trips for reconnaissance, inspection and similar work on location, surveys and construction projects. In 1923 the Railway Company purchased six passenger cars for use of survey parties on location and construction work on its Rosebud Branch and has since used both passenger automobiles and motor trucks on the location surveys and construction of the Redwater, Orofino, Bitter Root and Shelton Branches and on the location of the Peninsular Branch and the Yacolt Branch extension. On location work as

many passenger cars are furnished as are needed to transport the entire field party. On construction work each residency is supplied with one passenger car. A car for the use of the Engineer in general charge is also furnished. Trucks of one-half to one-ton capacity are used to transport supplies, camp equipment, etc., the number of course depending on requirements. These cars are shipped from one job to another and are replaced when worn out. The average number of such cars on hand has been about six. With the use of motor cars, the length of residencies on construction was increased approximately 25 per cent, depending of course on accessibility to roads.

Motor trucks assigned to B&B work are located in the larger terminals and around docks and are used in the transportation of men, materials and equipment. These trucks, however, are not used exclusively for B&B purposes, but are used wherever they fit in. The first unit was purchased in 1928 and has been added to as needed.

Southern Pacific Company

This road first started the use of motor trucks in 1920 when a one-ton truck was furnished the B&B force in Los Angeles. Since that time 28 additional units have been added, ranging in size from half-ton to 3½ tons capacity. In addition to the above, considerable use is made of trucks operated by the Stores Department for the movement of materials at terminals. The one-half-ton pick-up truck for general roustabout service has been found the most economical. The trucks are used for light carpenter and plumbing repairs in cities, for signal and track gangs where tracks are in streets, for light carpenter and plumbing repairs in the country, for signal maintainers on congested main lines where highways parallel the tracks and for small paint crews not equipped with outfit cars. The estimated economies range from 30 per cent to 50 per cent in time and in the movement of materials. It is found that one mechanic making light repairs can cover the territory of two men using motor cars where lines parallel 5 to 25 miles apart. This road plans the expansion of such motor truck service. Trucks have also been found of great advantage in pipe line construction in the movement of welding outfits, concrete mixers and the general handling of tools and equipment for all classes of construction work.

The variety of work performed, the difference in physical conditions and the limited data available preclude anything more than a general conclusion.

Conclusions

Substantial economies may be realized under certain conditions by the use of motor vehicles in the performance of certain kinds of maintenance and engineering work.

Recommendations

It is recommended that this report be received as information and the study of this subject discontinued.

Appendix I

(9) GANG ORGANIZATION AND METHODS OF PERFORMING MAINTENANCE-OF-WAY WORK, INCLUDING REVISION OF TIME STUDIES NOW IN THE MANUAL

C. H. R. Howe, Chairman, Sub-Committee; Lem Adams, Paul Hamilton, G. M. O'Rourke, E. L. Potarf, F. S. Schwinn, J. F. Dobson, J. H. Kelly, J. C. Patterson.

Your Committee in its consideration of this subject appreciates the fact that time studies of items of maintenance of way work are essentially detailed statements of the time required to perform each of the various operations that are involved in doing work. Methods and organizations are subject to change and modification in conformity with local conditions, but the fundamental operations of the job remain the same.

Originally all maintenance of way work was performed manually. The introduction of mechanical equipment presents many problems of economics that require, first of all,

a specific knowledge of the time necessary to perform the work by hand. On page 1455 of the 1929 Manual there appears a "Schedule for Renewing Rail Out of Face". This is a detailed statement of the net time required for laying rail under certain definite conditions; if these are changed the schedule must be adjusted. We do not think that it is incumbent upon this Committee to specify, or even indicate, the steps that should be taken to adapt such a schedule for use under the various requirements of local peculiarity. It is our purpose to deal only with basic studies; the estimation of allowances for lost time due to traffic, or other such causes, is a matter for the local estimator to determine.

There are, however, certain definite changes in general practice that have been introduced since the printing of the original rail laying study. The Committee now presents additions to the rail laying schedule to cover the change to the 39-ft. rail and the increase in the number of ties per rail.

SCHEDULE: RAIL-RENEWING OUT OF FACE BY HAND METHOD
SIX HOLE PLAIN BARS REPLACING FOUR OR SIX HOLE PLAIN BARS
SCHEDULE FOR 39′ RAILS AS WELL AS 33′ RAILS

Operation No.	*Schedule 10–33′ Rails 18 Ties Per Rail (Minutes)*	*Schedule 10–33′ Rails 20 Ties Per Rail (Minutes)*	*Schedule 10–39′ Rails 22 Ties Per Rail (Minutes)*	*Schedule 10–39′ Rails 24 Ties Per Rail (Minutes)*
1 Adzing before drawing spikes..	43	48	51	57
2 Setting up rail	90	90	105	105
3 Drawing one line of spikes.....	90	100	110	120
4 Lining out old rail	60	60	71	71
5 Plugging spike holes	25	28	31	33
6 Adzing	50	55	61	67
7 Cleaning rail seats	18	20	22	24
8 Driving down stubs and cracking up remaining spikes	18	20	22	24
9 Turning in new rail	28	28	28	28
10 Distributing bolts, nut locks and spikes	20	21	22	23
11 Placing splice bars and full bolting	140	140	140	140
12 Full spiking	110	122	134	147
13 Uncoupling old rail	110	110	110	110
Two flagmen during runs	84	84	84	84
Water boy, 1 for gang of 20 men	44	47	49	52
Foreman, 1 " " " 20 "	44	47	49	52
Total time for ten rails	974	1020	1091	1137
Total minutes for one foot	2.95	3.09	2.800	2.915
Standard Schedule: Hours per rail	1.623	1.700	1.820	1.895

If any of the above items are not performed, subtract corresponding time with allowance for supervision from totals and figure revised standard time.

When rail being replaced has bars with depending flanges the standard schedule becomes 1.673 (18 ties per rail), 1.750 (20 ties per rail), 1.870 (22 ties per rail) and 1.945 (24 ties per rail).

When rail is being laid with continuous bars the standard schedule becomes 1.740 (18 ties per rail), 1.817 (20 ties per rail), 1.937 (22 ties per rail) and 2.012 (24 ties per rail).

If it is necessary to draw more than one line of spikes on one side the standard schedule becomes 1.850 (20 ties per rail), 1.970 (22 ties per rail) and 2.045 (24 ties per rail).

When tie plates are being applied add 0.01 hour for each plate.

The development, and introduction, of mechanical aids in tie adzing, spike driving and pulling, bolt wrenching, and other features during the past few years has been very rapid. The possible variations in organization, size of gang and methods of procedure are many. It is now more essential than ever that the capacity of any individual machine, and the rate of performance of any particular operation be considered in terms of coordinating the progress of all the units of the work.

It is to be expected that future developments in the practice of laying rail will bring about further changes in organization. With this in mind the Committee does not consider that the publication in the Manual of rail laying schedules, covering extensive use of mechanical equipment, would be justifiable at this time.

We do, however, present for your information studies showing the organizations, equipment and production records of three railways on each of which the type of track construction varied in a marked manner.

On June 5, 1931, this Committee made an inspection of a rail laying organization on the Eastern Division of the Central Region of the Pennsylvania Railroad at Bellevue, near Pittsburgh, Pennsylvania.

New 131-lb. 39-ft. rail was being laid to replace old 130-lb. 39-ft. rail. However, shortly after this date, the same gang began laying new 152-lb. 39-ft. rail, replacing old 130-lb. 39-ft. rail and used the same organization and equipment. The following are notes on organization and equipment in use on this gang, designated by this railway as the Eastern Ohio-Lake rail train.

Work

Distribution by work train of rail, tie-plates, joint-bars, rail anchors, bolts, spikes, and tie plugs.

Dismantling old track, removing rail anchors, spikes, bolts, joint bars, rail and tie-plates.

Preparing bed for new rail, including plugging old spike holes, adzing, and painting adzed surfaces of ties with creosote.

Laying new rail, including setting tie-plates, setting rail, applying joint bars, bolting up, gaging, spiking, applying rail anchors, bevelling joints, and bonding rail ends.

Picking up rail and material, making proper classification.

Organization

Distributing material—Local forces:

2 foremen
1 work equipment engineer (crane operator)
14 laborers
—
17

Rail laying gang (special organized unit for laying rail—moved from point to point):

1 general foreman
1 inspector M. W. (mechanic)
1 clerk
2 foremen
2 assistant foremen
1 work equipment engineer (crane operator)
4 machine operators
78 laborers
—
90 total—Recruited from six Divisions of the Eastern Ohio-Lake General Division; each man holding rights on his home Division.

Commissary (operated by a contract commissary company):
- 1 clerk (in charge)
- 1 chief cook
- 1 second cook
- 3 dining car attendants
- 1 car cleaner
- 1 yardman

---

8 Total

Picking up material—Local force:
- 2 foremen
- 3 work equipment engineers (crane operators)
- 15 laborers

20

Bonding:
- 4 signalmen

Equipment and Machines Used

For distributing:
- 1 crawler crane

For picking up:
- 1 crawler crane
- 2 locomotive cranes

For laying:
- 1 Metalweld compressor—280 cubic feet free air per minute capacity, equipped with overhead extension carriers for supporting pneumatic spike pullers. Operates four to six Ingersoll–Rand 99-C track wrenches
- 4 Nordberg adzing machines equipped with 15½″ cutting heads
- 2 Nordberg grinders for sharpening cutting bits for adzing machines
- 1 Cullen–Friestedt Burro crane, 4-wheel, ½ swing type, 30-foot boom, capacity 2½ tons
- 1 12-tool, type 20, Ingersoll–Rand compressor equipped with air drive and cross trucks for operating 4 to 6 Ingersoll–Rand type CC-250 spike drivers and two Ingersoll–Rand 99-C track wrenches
- 1 Keystone joint bevelling machine
- 1 Madden rail layer (power) for emergency use
- 2 Class E motor cars (1 Casey–Jones 551 and 1 Fairmont A-5)
  Trailers, trucks, etc.

For bonding:
- 2 Everett power bonding machines

Train Equipment

Carried by special gang

- 1 water tank
- 1 commissary supply car
- 1 dining car
- 2 dining-kitchen cars
- 6 sleepers
- 1 recreation-office car
- 1 flat car
- 1 oil car
- 3 gondola cars
- 1 tool car

18

LINE-UP FOR WORK

Distributing (work train):
2 foremen
4 on rail
2 on splice-bars
1 on bolts and nutlocks
1 on anchors
1 on spikes and plugs
4 on tie plates
1 on joint plates
1 work equipment engineer (crane operator)
—
17

First unit (rail laying):
1 foreman
2 starting spikes
2 starting nuts
1 removing rail anchor
4 spike pullers
1 compressor operator
2 denutters (air wrenches)
1 removing bond wires
1 welder (not carried on train)
2 joint spiker
1 removing splices
2 removing missed spikes
2 throwing out rail
1 removing tie plates
4 lowering ballast
2 driving down spike stubs
2 setting tie plugs
2 driving tie plugs
1 sweeping ties
1 water carrier
—
35

Summary (first unit):
1 foreman
1 assistant foreman
1 machine operator
32 laborers
—
35

Second unit (rail laying):
1 foreman
1 assistant foreman
4 adzers
1 machine operator (for adzing machine)
1 applying creosote
5 setting tie plates
5 setting in rail
1 work equipment engineer
2 grinding adzing bits
1 oiling rail ends
4 applying splices
3 gaging and spot spiking
5 setting spikes
4 air wrenches

1 compressor operator
5 spike drivers
2 applying rail anchors
2 tightening bolts
2 bevelling joints
1 toolman
1 water carrier
—
52

Summary (second unit):
1 foreman
1 assistant foreman
1 work equipment engineer
3 machine operators
46 laborers
—
52

Total (rail laying):
1 general foreman
1 clerk
1 inspector M. W. (mechanic)
35 first unit
52 second unit
—
90

Picking up (work train):
2 foremen
6 on rail
3 on splices
2 on scrap
4 on tie-plates
3 work equipment engineers (crane operators)
—
20

Bonding:
4 signalmen

Total forces:

Distributing	17
Laying	90
Picking up	20
Bonding	4
	131

The maximum laid by this gang was 627 rails 39 ft. long, with a daily average of 272 rails. This gang normally took a stretch of track and closed it for traffic at 8:01 a.m. each day without anything unloaded or distributed, and worked eight (8) continuous hours without stopping for noon meal and closed at 3:59 p.m., with all tools and equipment loaded on their work train and all old rail, scrap and other released materials picked up clean, leaving the track open for traffic. All new materials, tools, etc., were kept on cars between these eight-hour working periods, the men lived in suitable quarters in outfit cars and the entire camp train was ready to move for work at any point desired when they closed the day's work each afternoon.

This was one of the several gangs on the Pennsylvania specialized through training and with adequate equipment of mechanical appliances which were kept on this one class of work throughout the year. It was a very efficient organization and did much more and better work than a larger not specialized gang equipped with old-style hand tools could accomplish in the same allotted time under similar conditions otherwise.

In 1931 for handling rail laying work on the Central Region, two specialized gangs were used, both organized on the same basis, but using slightly different appliances. The gangs were known as the Western-Pennsylvania Northern (W.P.N.) and the Eastern Ohio-Lake (E.O.L.), the names being derived from the General Divisions from which the gangs were recruited and over which territory they worked.

The Western Pennsylvania-Northern gang was equipped with Nordberg spike pullers, a self-contained power unit which had been introduced and developed during the year 1930; while the Eastern Ohio-Lake gang was equipped with Ingersoll-Rand air spike pullers suspended from overhead arms extended both front and back from a special built Metalweld self-propelled air-compressor. There was also a difference in the types of cranes used. The Western Pennsylvania-Northern gang was equipped with a 12-ton gas-driven Ohio locomotive crane, and the Eastern Ohio-Lake gang with a model No. 10, 180° swing Burro crane. The locomotive crane was used to a greater extent in multiple track territory where it was necessary to unload and load compressors and other machines each day where it was possible to obtain the use of track for longer intervals. The Burro crane was used mostly in single and double-track territory where, on account of traffic, it was necessary to close up and clear the track for traffic more often during a day's run, which was done by running to convenient side-tracks or setting all working equipment off the track by means of the transverse wheels on temporary set-offs built adjacent to track on which working. While tracks were occupied by the rail-laying outfit it was used to the fullest extent possible for distributing and picking up material.

The work train line-ups shown by Fig. 1, Typical Organization for Rail Laying, were used to a large extent but often varied to meet local conditions. At times, especially in multiple track territory where the use of track was obtained for the entire day and where a work train in conjunction with the rail laying forces for handling the machines was necessary, the work train was composed of two engines, one working with cars containing material to be applied and distributing it ahead of the gang and the other in the rear of the gang picking up material so that when the procession had passed the work was completed.

With the set-up as shown on the plan, it was possible to distribute rail faster than it could be laid so that one engine was used with the work train and rail was all distributed in advance, and then the work train with a slightly different organization, similar to that shown on plan was moved back of gang for picking up, the entire operation being simultaneously completed.

The statement given below shows the amount of work performed, the machines used with cost of each, and an estimate of the total cost of laying rail.

PENNSYLVANIA RAILROAD

Central Region

REPORT, RAIL LAYING—YEAR 1931

General Information

	West Pennsylvania-Northern	*Eastern Ohio-Lake*
Total amount rails laid	54,250	33,247
Total tonnage rails laid	36,737	22,283
Maximum rails laid per day	627	471
Minimum rails laid per day	112	76
Average number rails per day	313	224
Average number tons per day	212	150
Number of days laying rail	173	148

Two trains laid in 321 train-days; 59,020 tons—or
184 tons per day per train—or
368 tons per day for two trains

SUMMARY OF ALL COSTS

			Per Ton
I.	Forces laying rail		$1.94
II.	Distribution of rail and other track material (estimated cost)		0.50
III.	Picking up rail and other track material		0.54
IV.	Other costs:		
	a) Machines (interest, annuity to replace, and repairs)	$0.35	
	b) Camp (repairs and supplies)	0.13	
	c) Moving camp and equipment	0.09	
	d) Miscellaneous (fuel, water, stationery)	0.10	0.67
	Average total cost of laying rail, 1931		$3.65

(I) FORCES LAYING RAIL

Cost per Eight-Hour Day

TITLE	Rate		West-Pennsylvania-Northern		Eastern-Ohio-Lake	
	Monthly or hourly	Daily	No. of Men	Cost per Day	No. of Men	Cost per Day
General Foreman	$195.00	$ 9.21	1	$ 9.21	1	$ 9.21
Inspector M. W.	165.00	7.80	1	7.80	1	7.80
Clerk	122.50	5.79	1	5.79	1	5.79
Foreman	142.50	6.73	2	13.46	1	13.46
Engr. work equip.	0.68	5.44	1	5.44	1	5.44
Asst. foreman	0.54	4.32	2	8.64	2	8.64
Machine operators	0.54	4.32	8	34.56	4	17.28
Laborers	0.41	3.28	76	249.28	78	255.84
Daily Labor Cost				$334.18		$323.46
Rail train forces			92		90	
Local forces:						
Welder (cutting bolts)	0.82	6.56	1	6.56	1	6.56
Signalmen (bonding)	0.82	6.56	2	13.12	2	13.12
Signalmen helpers (bonding)	0.58	4.64	2	9.28	2	9.28
Total average daily cost				$363.14		$352.42
Total force			97		95	

Daily rates for monthly men calculated on a basis of five days a week (the days actually laying rail).

(II) Distributing Rail and Other Track Material (Estimated Costs)

Distributing (cost per day):		
2 crawler cranes—first cost $8,500	$17,000.00	
15 years' life at 6% depreciation—2 cranes	$ 730.00	
Interest at 6% on $17,000	1,020.00	
Repairs $500 per crane	1,000.00	
Total	$ 2,750.00	
Assume 200 working days per crane per year:		
Cost per crane per day	$ 13.75	
Gas and oil	10.00	$ 23.75
Labor:		
1 foreman at $142.50	6.73	
2 work equipment engineers at $0.68 per hour	10.80	
19 laborers at 40 cents per hour	60.80	78.33
Work train charges (including overtime):		
Average cost per hour per train	$ 11.00	
Cost per 10-hour day		110.00
Total cost distributing force		$212.08

Such force will distribute rail at the rate of 8 cars per day (560 rails or 425 tons) 39-ft., 131-lb. rail, at 50 cents per ton.

(III) Estimated Cost of Picking up Rail and Other Track Material

2 crawler cranes—first cost $8,500 each	$17,000.00	
1 locomotive crane	12,000.00	
Total	$29,000.00	
Annual costs:		
Depreciation $29,000 at 6%—15 years' life	1,245.00	
Interest—6% on $29,000	1,740.00	
Repairs—$500 per crane	1,500.00	
Total	$ 4,485.00	
Assume equipment used 200 days per year:		
Daily costs 4485/200 X	$ 22.42	
Gas and oil	15.00	
Total cost equipment		$ 37.42
Force:		
1 foreman at $142.50	$ 6.73	
3 work equipment engineers at 68 cents per hour	16.32	
15 laborers at 40 cents per hour	48.00	71.05
Work train charges (including overtime):		
Average cost per hour per train	$ 11.00	
Cost per 10-hour day		110.00
Total cost picking up		$218.47

This force and equipment will load rail at the rate of 600 rails per day (384 tons), 33-ft., 130-lb., at a cost of 54 cents per ton.

(IV) Cost of Machines Used on Rail Trains

ITEM	Cost	Western Pennsylvania Northern		Eastern-Ohio-Lake	
		Number	Total Cost	Number	Total Cost
Metalweld compressor	$ 4,600			1	$4,600
Ingersoll-Rand compressor	3,610	2	$ 7,220	1	3,610
Ingersoll-Rand spike puller	225			8	1,800
Ingersoll-Rand type 99C wrenches	275	5	1,375	5	1,375
Nordberg spike puller	1,100	6	6,600		
Nordberg adzers	1,475	4	5,900	4	5,900
Nordberg grinders	100	2	200	2	200
Ohio locomotive crane	12,395	1	12,395		
Burro crane	5,425			1	5,425
Ingersoll-Rand spike driver	195	6	1,170	6	1,170
Keystone beveler	600	1	600	1	600
Everett power drill	584	1	584	1	584
Madden rail layer	851	1	851	1	851
Push cars	150	2	300	6	900
Motor cars	450			2	900
Bonding drill	375	1	375	1	375
Trailer cars	200			4	800
Total investment in machines used			$37,570		$29,090

Total investment in machines on both trains $66,660

Summary of Costs per Ton per Rail Laid

1. Forces (actual laying):
   - Average daily costs Western-Pennsylvania-Northern gang...... $363.14
   - Average daily costs Eastern Ohio-Lake gang................ 352.42
   - Total daily costs, 2 gangs........................ $715.56
   - Distributed to 368 tons per day two trains
     - Average cost per ton of rail.......................... $1.94
2. Distributing rail and other track material:
   - Cost per ton of rail.................................... 0.50
3. Picking up rail and other track material:
   - Cost per ton of rail.................................... 0.54
4. Other charges:
   - a) Machines
     - Yearly cost, machines Western Penn.-Northern gang... $11,143
     - Yearly cost, machines Eastern Ohio-Lake gang........ 9,632
     - Total yearly cost, 2 trains.................. $20,775
     - Distributed to 59,020 tons of rail laid
       - Average cost per ton of rail.......................... $0.35
   - b) Camp expenses
     - Repairs (only) to 34 cars retired from reg. service at $200 per car .... $ 6,800
     - Bedding, laundry (not done by commissary company) and miscellaneous camp expenses per year........ 1,200
     - Total yearly cost .... $ 8,000

Distributed over 59,020 tons		
Average cost per ton of rail...........................		0.13
c) Moving camp and equipment		
Work train or other crew moved, each train average once a week—8 hrs. wk. train at $11.00...........$	88	
Distributed over week's work (5×184 tons) 920 tons, or cost per ton of rail.........................		0.09
d) Miscellaneous expenses		
Water, fuel, office, medical and other supplies—$100 per week per train		
Distributed over week's work (5×184 tons) 920 tons, cost per ton rail		0.10
Total "other charges"—Average cost per ton of rail........		0.67
Average total cost per ton of rail........................		$3.65

It is noted that the number of rails laid per day varied considerably, the minimum being 76 and the maximum 627, which number was obtained in replacing rail of like section not involving change of tie-plates and adzing ties. The 76 were laid through a tunnel under adverse weather conditions with unusual heavy traffic.

The statement shows the cost of the work in detail. There is a variation in the amount of work done and average cost per ton between the two gangs which is the result of one gang working to a large extent in territory where it was possible to obtain uninterrupted use of track for longer intervals.

Equipment and machines costing $66,660 were used with the two gangs; the interest on which, together with repairs and an annuity to replace the machines when worn out or retired on account of obsolesence, amounted to $20,775 per year or about $130 per day actually used, or $0.35 per ton of rail laid.

The cost of laying rail, including all sections and under all conditions during 1931 averaged $3.65 per ton including all costs.

The foregoing information on the cost and the operation of these gangs is taken from information furnished to the International Railway Congress Association for its XIIth Session, Cairo, Egypt, 1933 on "The Use of Mechanical Appliances in the Permanent Way Maintenance and in Track Relaying," by F. M. Thomson, Chairman of A.R.E.A. Committee XXII.

Chesapeake & Ohio Railway

The organization of rail gangs on this railroad varies but little from that of the Pennsylvania and other railways that are extensively equipped with power tools. It is shown, however, as an example of those railways that follow the practice of securing the tie plates to the ties. In this case the fastenings were lag screws and double convolution spring washers, the rail being fastened with cut spikes.

One of the advantages claimed for this style of track construction is that the cost of relaying, after tie plates have once been secured, will be reduced materially. The Committee presents a time study showing the organization used and the actual result of a day's laying where tie plates are to be lag screwed for the first time. The number of rails, 480, is an ordinary day's run for this gang which has laid as high as 668 rails per day. As soon as information is available the Committee will report on the changes made in this organization when laying on fixed tie plates, and the resultant savings obtained by this method of handling work. Preliminary estimates indicate that the cost of laying should be reduced approximately two-thirds.

Fig. 2 illustrates rail laying organization on the Chesapeake & Ohio Railway when rail is dismantled ahead of crane.

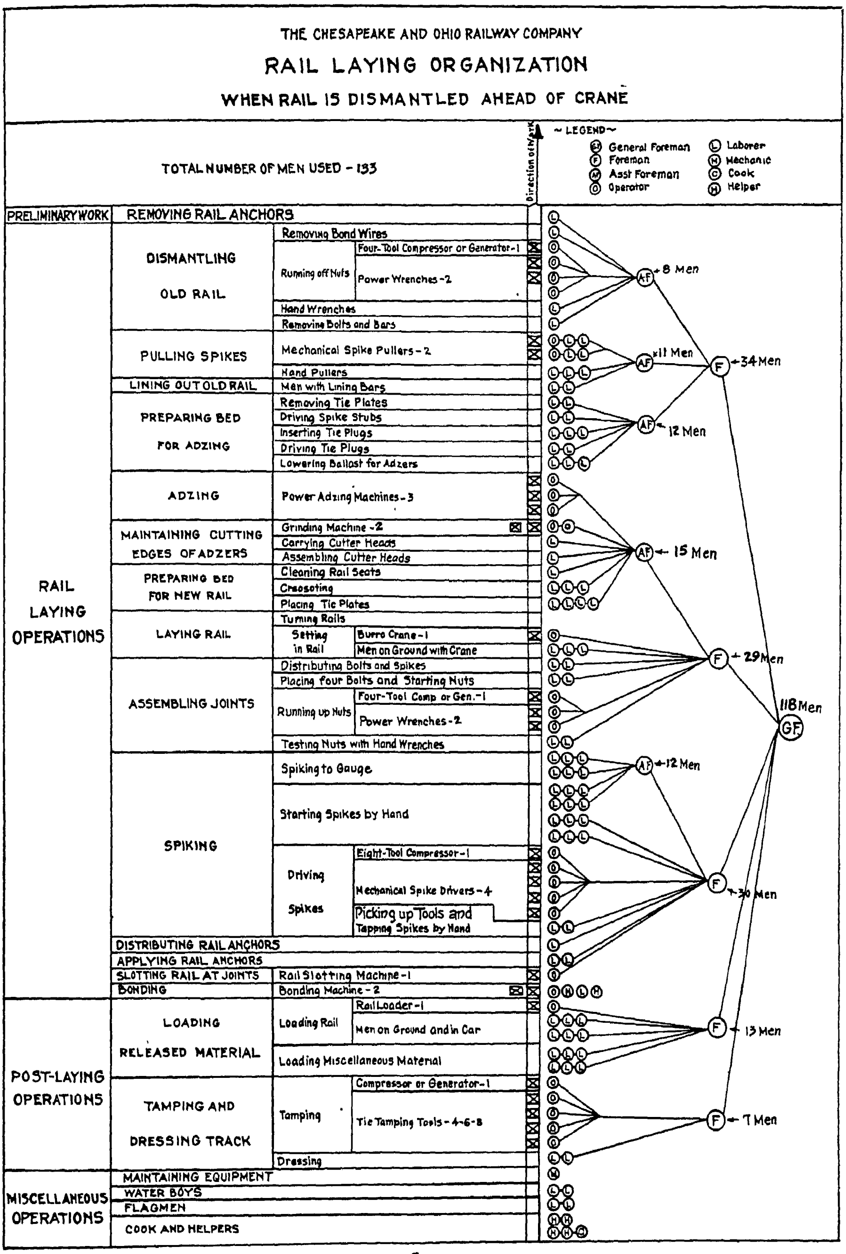


Fig. 2.—Rail Laying Organization on the Chesapeake & Ohio Railway.

Estimated Annual Cost of All Machines Used on Rail Trains

(Including Interest on Investment, Annuity to Replace, and Repairs)

ITEM	*First Cost*	*Average Life Years*	*6 Percent interest on investment*	*6 Percent annuity to replace*	*Estimated yearly repairs*	*Total annual charges per Machine*	*Western Pennsylvania-Northern*		*Eastern Ohio-Lake*	
							No. used	*Total annual charge*	*No. used*	*Total annual charge*
Metalweld compressor	$ 4,600	10	$ 276	$ 349	$ 500	$ 1,125			1	$ 1,125
Ingersoll-Rand compressor	3,610	10	217	274	500	991	2	$ 1,982	1	991
Ingersoll-Rand spike pullers	225	5	13	40	150	203			8	1,624
Ingersoll-Rand 99C wrenches	275	5	16	49	50	115	5	575	5	575
Nordberg spike pullers	1,100	5	66	195	200	451	6	2,766		
Nordberg adzers	1,475	5	89	262	150	501	4	2,004	4	2,004
Nordberg grinders	100	5	6	18	10	34	2	68	2	68
Ohio crane	12,395	15	744	532	1,000	2,276	1	2,276		
Burro crane	5,425	15	326	233	500	1,059			1	1,059
Ingersoll-Rand spike drivers	195	6	12	29	75	116	6	696	6	696
Keystone bevelers	600	4	36	137	100	273	1	273	1	273
Power drill	584	8	35	68	60	163	1	163	1	163
Madden rail layer	851	10	51	65	10	126	1	126	1	126
Push cars	150	5	9	27	20	56	2	112	6	336
Motor cars	450	10	27	34	50	111			2	222
Bonding drills	375	8	23	44	35	102	1	102	1	102
Trailer cars	200	5	12	35	20	67			4	268
Total yearly cost to trains								$11,143		$9,632

The performance on the days laying observed was 18,720 lin. ft. of rail in 872 man-hours. This is at the rate of .0465 man-hours per foot, or 245.52 man-hours per mile of rail. The time of the surfacing gang is not included.

The application of the lag screws does not take place at the time the rail is laid, but is done subsequent to such respacing of ties as may be necessary. The organization and equipment of the lag screw gang is as follows:

EQUIPMENT

Eight Tool Tie Tamper Compressor, or
Six Tool Tie Tamper Electric Generator
Four Wood Boring Machines or Electric Drills
Two Air or Electric Wrenches
Necessary cans for pouring creosote in holes.

ORGANIZATION

Foreman	1
Compressor Operator (also sharpens bits)	1
Drill Operators	4
Wrench Operators	4
Distributing Lag Screws	1
Pouring Creosote	2
Total	13

The time required for applying the lag screws, based on the placing of 1,501,340 screws in the year 1931, was at the rate of .041 man-hours per screw, or 219.44 man-hours for 5486 lag screws per mile of rail. No lag screws were applied on joint ties. Other charges for this work per mile of rail were: Creosote \$4.50, Gasoline, oil and other supplies \$4.28, Drill Bits \$4.17.

The total labor cost for laying this rail (exclusive of unloading and picking up) and applying the lag screws was $.047 + .041 = .088$ man-hours per foot of rail.

The total man-hours for laying (excluding distribution and picking up) one mile of 130-lb. R.E. section rail with six hole angle bars, and including the lag screw application would be $245.52 + 219.44 = 464.96$ man-hours.

GEO Track on the Louisville & Nashville Railroad

As this type of construction presents a different method of fastening rail while at the same time securing tie plates to the ties, the Committee presents the following time study showing equipment and organization used in laying GEO construction on the old ties that were in the track. The 100-lb. R.E. section rail being replaced by 110-lb. section. The work outlined in the study was part of a two-mile section installed by this railroad. The gang had but one day's previous experience with this type of construction. It is our opinion that with more practice, and longer stretches to lay, the cost of the work would be reduced materially.

EQUIPMENT

1 #20 Burro Crane setting in rail
1 #10 Burro Crane with boom supporting air hose, and used as motive power for air compressor
2 Nordberg adzing machines
2 8-tool non-self-propelled air compressors (Ingersoll-Rand)
1 12-tool non-self-propelled air compressors (Ingersoll-Rand)
1 Track bolt wrench
2 Lag screw wrenches
4 Air boring wrenches
4 Clip wrenches

ORGANIZATION

1 Foreman
20 Men with claw bars and lining bars, stripping track and throwing out coupled rail
1 Foreman
2 Adzers
2 Grinding and changing bits

1 Foreman
1 Burro crane operator
12 Men creosoting ties, placing plates, setting rail
3 Men with push cars (2) carrying creosote, etc.
4 Men with push cars distributing clips, lag screws, bolts, etc.
1 Man adjusting plates

1 Foreman
2 Power track bolt wrench operators
1 Compressor operator
4 Clip bolt wrench operators

1 Foreman
6 Men gaging, partly driving cut spike each four or five ties, at either end of plate to hold gage
1 Man with slip punch centering lag screw holes
1 Man boring lag screw holes for gaging

1 Foreman
1 Compressor operator
1 Burro crane operator
4 Machine borer operators
1 Compressor operator
10 Men setting lag screws, etc. (2 power wrenches)
4 Men gathering tools, etc.

2 Men bonding joints
2 Men helping bonders

4 Water boys
1 Flagman

96 Total

The performance on the day's laying observed was 7020 lin. ft. of rail in 960 man-hours. This is at the rate of .137 man-hours per foot of rail, or 723.36 man-hours per mile of rail. As in the case of other types of construction where the plates are secured to the ties, future rail renewals should be done much more quickly. It is estimated that the time required for relaying, where the same section of rail is used, is but one-third of the time required for the original GEO installation on old ties.

Recommendation

1. The Committee recommends that the subject matter in the Manual beginning with Exhibit A on page 1449 to and including the first three paragraphs on page 1466, be withdrawn.

2. The Committee recommends that this report be received as information and the subject continued.

REPORT OF COMMITTEE XX—UNIFORM GENERAL CONTRACT FORMS

F. L. NICHOLSON, *Chairman;*
C. FRANK ALLEN,
E. H. BARNHART,
W. H. BRAMELD,
B. S. DICKERSON,
R. P. EUBANK,
W. D. FAUCETTE,
F. H. FECHTIG,
J. P. HANLEY,
B. HERMAN,
J. C. IRWIN,
A. C. JACKSON,
J. S. LILLIE,
S. L. MAPES,
A. A. MILLER,
O. K. MORGAN,
C. B. NIEHAUS,
H. A. PALMER,
W. G. NUSZ, *Vice-Chairman;*
W. M. POST,
J. A. RUSSELL,
CHARLES SILLIMAN,
HUNTINGTON SMITH,
J. S. THORP,
C. A. WILSON,
JOHN WORLEY,
Committee.

To the American Railway Engineering Association:

The subjects assigned and now under consideration by the Committee are of such nature as to require collaboration with other Committees of this Association, and in addition thereto conferences and correspondence with other organizations, having to do with the use of such forms, with the view to reconciling, as nearly as possible, the differences of opinion and interests, thus when the forms are completed and ready for action by this Association they will be acceptable as a fair guide or base from which contracts or agreements may be prepared to cover any local condition, and can be used, in most cases, in the exact form as recommended. It should not be expected, however, that this Committee can secure in every instance the unqualified approval or adoption of such completed forms by other organizations—where interests differ, opinions likewise differ. Because of these difficulties in preparation of the forms, the Committee's report is largely one of progress, which assuredly is being made in all subjects.

The Committee reports:

1. Revision of Manual (Appendix A).

This subject is being given serious consideration and studies are being made with the intent to abbreviate and standardize phraseology so that paragraphs covering the same requirements may be used in all forms. Revisions are desirable in one or two forms to better conform to present practice; none of these, however, are of such nature as to require handling at this time. They will be covered before the next issue of the Manual, or earlier if found desirable.

The Committee has no revisions to recommend at this time.

2. Form of Agreement for the Purchase of Electrical Energy in Large Volume (such as required for traction purposes), collaborating with Committee XVIII—Electricity (Appendix B).

The Committee submitted a tentative form of agreement at the last annual convention, with the request that all parties concerned submit constructive criticisms and suggestions. The result has been most gratifying. The Committee is now giving consideration to these recommendations and conferences will be necessary before further action can be made.

3. Form of Conveyance of Title Granting the Right to Construct and Maintain Air Right Buildings over Railway Property (Appendix C).

Considerable progress has been made in gathering information and in the preparation of the form required under this assignment, but due to the serious illness of the Chairman of the Sub-Committee, the Committee simply reports progress.

4. Form of Agreement for Pipe Line Crossings under Railway Tracks, collaborating with Committees I—Roadway, and XIII—Water Service and Sanitation.

Bulletin 349, September, 1932.

5. Form of Agreement for Use of Railway Property by Pipe Lines paralleling the Railway, with special reference to pipe lines carrying high pressure inflammable oils and gas, collaborating with Committee I—Roadway (Appendix D).

The Committee is of the opinion that one form of agreement can be drawn to embrace these two assignments, the first draft of which is printed in this report as Appendix D, and is submitted for discussion and as a progress report.

6. Form of Agreement with Public Authorities for Highway Grade Crossing Elimination or Separation, collaborating with Committee IX—on Grade Crossings (Appendix E).

This is a subject requiring the most careful consideration and investigation of the Committee. The information gathered by Committee IX—on Grade Crossings and the studies of this Committee will be of valuable assistance to the members.

The Committee has no form of agreement to present at this time.

The Sub-Committee report is printed in this report as Appendix E.

Respectfully submitted,

THE COMMITTEE ON UNIFORM GENERAL CONTRACT FORMS,

F. L. NICHOLSON, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. C. Irwin, Chairman, Sub-Committee; C. Frank Allen, W. H. Brameld, O. K. Morgan, W. G. Nusz.

Your Committee has no revisions to recommend at this time.

Appendix B

(2) FORM OF AGREEMENT FOR THE PURCHASE OF ELECTRICAL ENERGY IN LARGE VOLUME (SUCH AS REQUIRED FOR TRACTION PURPOSES)

W. H. Brameld, Chairman, Sub-Committee; E. H. Barnhart, S. L. Mapes, H. A. Palmer, W. M. Post, J. S. Thorp.

Your Committee reports progress with Form of Agreement for the Purchase of Electrical Energy in Large Volume. A complete summary of all criticisms and suggestions received was prepared and furnished the members of the Sub-Committee and to the members of Committee XVII of the Electrical Section, with request that each member give recommendation on the comments received. These are now being tabulated and will form the basis for final revision of the proposed Form of Agreement.

Action Recommended

That this be accepted as a progress report and that the assignment be continued.

Appendix C

(3) FORM OF CONVEYANCE OF TITLE GRANTING THE RIGHT TO CONSTRUCT AND MAINTAIN AIR RIGHT BUILDINGS OVER RAILWAY PROPERTY

O. K. Morgan, Chairman, Sub-Committee; R. P. Eubank, C. B. Niehaus, Huntington Smith.

The information gathered on this assignment has enabled the Committee to draft a tentative form which is now under discussion, but not ready for presentation to the Association.

Appendix D

(5) FORM OF AGREEMENT FOR PIPE LINE CROSSINGS UNDER RAILWAY TRACKS AND FOR THE USE OF RAILWAY PROPERTY BY PIPE LINES GENERALLY PARALLELING THE RAILWAY

Charles Silliman, Chairman, Sub-Committee; F. H. Fechtig, J. P. Hanley, B. Herman, A. C. Jackson, J. S. Lillie, J. A. Russell.

Your Committee submits the following form as a first draft.

Effort is being made to co-operate with the American Petroleum Institute and Committees I and XIII. A conference has been held with representatives of the American Petroleum Institute and the general approval of Committees I and XIII has been obtained.

It is suggested the subject be continued until further hearing from the American Petroleum Institute.

This Agreement made this .... day of ...., 19...., by and between ...., hereinafter called the Railway Company and ...., hereinafter called the Licensee,

Witnesseth:

Whereas the Licensee desires to construct, reconstruct, maintain and operate a ...... inch .... pipe line for the handling of ...., under the tracks and/or upon the property of the Railway Company, at or near ...., County of ...., State of ...., substantially as shown on Plan No. ...., dated ...., designated as ...., and the Specifications hereto attached and made a part hereof,

It is mutually agreed as follows:

(1) The Railway Company grants permission to the Licensee to construct, reconstruct, maintain and operate said pipe line upon its property and/or under its tracks in accordance with said Plan and the Specifications hereto attached and forming a part hereof, subject to the conditions and requirements of this Agreement.

(2) In consideration of this license, the Licensee shall pay to the Railway Company the sum of $....................................

(3) The Licensee hereby acknowledges the title of the Railway Company in and to the premises described in this Agreement and agrees never to assail nor resist said title.

(4) The Licensee agrees at its own cost, subject to the supervision and control of the Railway Company's Chief Engineer or other designated officer, to lay and maintain the pipe line in such manner and of such material that it will not at any time be a source of danger to or interference with the safe operation of the railway. Arrangements must be made with the Chief Engineer or other designated representative of the Railway Company for the date and time for doing such work. Any work neglected by the Licensee or the contractor doing the work in connection with this laying or maintenance of the pipe line, or which the Railway Company would prefer to do itself, may be done by the Railway Company, and the Licensee agrees to reimburse the Railway Company therefor.

(5) If any commission or other regulatory body duly constituted and appointed in compliance with Federal laws or the laws of the State in which the pipe line herein referred to is situated, shall by ruling or other general order prescribe a higher degree of protection than set forth herein or required under the attached Specifications, then said ruling or general order shall be complied with for the pipe line referred to herein.

(6) The pipe line, if conveying gas, natural or artificial, oil, gasoline or other inflammable matter, matter under pressure, or matter which from its nature may cause damage, shall be laid and maintained when within .... feet on each side of the nearest track inside an auxiliary or protecting pipe, and at a depth of not less than .... below the base of rail where passing under the tracks, as set forth in the Specifications. (In the case of low pressure lines, modification of these requirements may be made with the approval of the Railway Company.)

(7) If the Licensee desires or is required as herein provided to revise, renew, add to or alter in any manner the pipe line, or to increase its operating pressure or change the purpose for which the pipe line is used, it shall submit plans to the Railway Company and procure the approval thereof in writing before any work or increase of pressure or change of use in said pipe line is undertaken, and the terms and conditions of this Agreement shall apply thereto unless changed by mutual consent of the parties hereto.

(8) The Licensee agrees that in any future alteration of the alignment or grade of the Railway or the laying of additional tracks, the Licensee will bear the entire expense of changing said pipe line, to permit of said alterations of the alignment or grade of the railway or the laying of additional tracks, so that the pipe line will continue to conform to the requirements of the Railway Company.

(9) The Licensee as part of the consideration for this grant, hereby releases and waives any right to ask for or demand damages for or on account of loss of or damage to the pipe line and contents thereof, whether attributable to the fault, failure or negligence of the Railway Company or otherwise.

(10) The Licensee shall indemnify, protect and save harmless the Railway Company from and against all claims, suits, costs, charges, causes of action, or damages made upon or incurred by the Railway Company in connection with this license.

(11) This license is given and accepted under the express condition that it may be terminated at any time by either party upon .... notice in writing to be served upon the other party, and that upon the termination of this Agreement the Licensee shall abandon the use of the pipe line and, should it be required by the Railway Company, remove the same and under the direction of the Railway Company restore all the properties of the railway to a condition equal to that in which they were prior to the placing of the pipe line.

(12) In case the Licensee shall fail to remove its property or to restore the premises as aforesaid within .... of said termination, the Railway Company may proceed with such work at the expense of the Licensee.

(13) No termination of this Agreement shall release the Licensee from any liability or obligation which may have attached or accrued previous to or which may be accruing at the time of such termination.

(14) This Agreement shall inure to the benefit of and be binding upon the legal representatives and successors of the parties hereto, but no assignment hereof by the Licensee, its legal representatives and successors, shall be binding upon the Railway Company without the written consent of the Railway Company.

In Witness Whereof, the parties hereto have executed this Agreement in .... the day and year first above written.

Witness:

....	....
	By ....
Witness:	
....	....
	By ....

Appendix E

(6) FORM OF AGREEMENT WITH PUBLIC AUTHORITIES FOR HIGHWAY GRADE CROSSING ELIMINATION OR SEPARATION

W. G. Nusz, Chairman, Sub-Committee; B. S. Dickerson, W. D. Faucette, A. A. Miller, C. A. Wilson and John Worley.

A number of different railroads have responded to your Committee's request and furnished agreements covering the elimination or separation of grade crossings in different states and Canada. These have been carefully studied and considerable time spent on the preparation of an agreement, but the Committee is not ready to submit a tentative form for consideration of the Association at this time and recommends that the subject be continued.

REPORT OF COMMITTEE I—ROADWAY

C. W. BALDRIDGE, *Chairman;*
J. B. AKERS,
J. B. ARTER,
H. B. BARRY,
E. J. BAYER,
A. E. BOTTS,
W. G. BROWN,
T. A. BURGESS,
G. H. BURNETTE,
PAUL CHIPMAN,
L. J. DRUMELLER,
L. C. FROHMAN,
J. A. GIVEN,
J. N. GRIM,
G. F. HAMILTON,
H. H. HARMAN,
DANIEL HILLMAN,
F. W. HILLMAN,
R. M. JOLLEY,
G. E. LADD,
W. J. LANK,
H. W. LEGRO,
E. R. LEWIS,
H. T. LIVINGSTON,
W. F. MONAHAN,
W. A. MURRAY,
J. C. NICKERSON,
J. A. NOBLE,
ROSCOE OWEN,
E. H. PIPER,
W. C. PRUETT,
W. M. RAY,
G. S. FANNING, *Vice-Chairman;*
C. S. ROBINSON,
L. S. ROSE,
C. S. SAMPLE,
P. T. SIMONS,
E. M. SMITH,
W. C. SWARTOUT,
H. M. SWOPE,
J. B. TRENHOLM,
JAMISON VAWTER,
O. H. WAINSCOTT,
THOMAS WALKER,
H. N. WHITE,
F. E. WIESNER,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report covering the following subjects:

1. Revision of the Manual.

No revisions recommended this year.

2. Methods of Roadbed Drainage (Appendix B).

This report is a continuation of the report on the same subject as made and adopted last year, and it is the Committee's recommendation that the matter in Appendix B, beginning with the words "French or Rock Drains" on the first page of the report and ending with Article 9, be adopted for inclusion in the Manual, following the matter adopted last year.

3. Study the service life of fence wire and specifications for railway fence wire (Appendix C).

It is recommended that this report be accepted as information.

4. Investigate the use of portable cribbing in place of rigid retaining walls and the utility of the different kinds of portable cribbing (Appendix D).

It is recommended that the report be accepted as information.

5. Physical properties of soils and their effect upon roadbed performance (Appendix E).

It is recommended that the report be accepted as information.

6. Drainage areas, water runoffs, and the proper size of waterway openings required under varying conditions (Appendix F).

It is recommended that the report be accepted as information.

7. Methods of correcting soft spots in railway roadbed where it is impracticable to stabilize by drainage (Appendix G).

It is recommended that the report be accepted as information.

8. Specifications for overhaul in grading contracts and a recommended method of calculating overhaul (see Appendix E, page 315 of Bulletin No. 342, December 1931, or page 315 of Vol. 33 of the Proceedings.)

This subject was reported on at the 1932 Convention and was offered as information with the request that the subject be reassigned for further study. After making a further study of the subject the Committee decided to offer the report of last year with the recommendation that it be adopted for inclusion in the Manual.

Bulletin 349, September, 1932.

9. Desirable width of roadbed in cuts and on fills, and desirable slopes of banks under varying conditions of present-day loadings (Appendix I).

It is recommended that the subject be accepted as information.

10. Investigate methods of protection against drifting snow on line of road and means and methods of removing or disposal of snow in yards and terminals (Appendix J).

It is recommended that the subject be accepted as information.

11. Specifications for galvanizing metal pipe culverts.

Conditions beyond the control of the members of the Committee made necessary the resignation from the Sub-Committee chairmanship of the member originally assigned. The succeeding Sub-Committee Chairman collected considerable valuable data, but not sufficient to justify a report at this time. The Committee therefore reports progress.

12. Specifications for pipe line crossings under railway tracks (Appendix K).

The report is offered with the recommendation that it be adopted for inclusion in the Manual.

Respectfully submitted,

THE COMMITTEE ON ROADWAY,

C. W. BALDRIDGE, *Chairman.*

Appendix B

(2) ROADBED DRAINAGE

G. S. Fanning, Chairman, Sub-Committee; L. J. Drumeller, G. E. Ladd, E. R. Lewis, W. F. Monahan, J. C. Nickerson, E. H. Piper, C. S. Sample, E. M. Smith, H. M. Swope.

Consideration of this subject has been continued in accordance with the outline adopted in 1931 (Proceedings, Vol. 32, page 170) and the following report is offered for publication in the Manual:

French or Rock Drains

10. French or Rock Drains are underground passages for water through the interstices among stone placed loosely in a trench. They have proved particularly useful in draining embankments made of water-retaining materials, which show a tendency to heave or slide when wet, and also in curing slides in similar materials in cuts and in side hill cut-fill sections.

French or Rock Drains should be constructed transversely of the embankment or slide at intervals determined by the conditions; in the most troublesome cases it is seldom necessary to place them closer together than forty feet center to center.

The trench, with a width of four to five feet, should be excavated to a depth of at least two feet below the bottom of ballast or water pockets or unstable material. The trench should be thoroughly cribbed; the use of trench jacks is recommended. Cribbing may be removed as the trench is filled with stone. From the toe of the embankment, the bottom of the trench should rise on a grade of at least 5 per cent and terminate normally under the far end of the ties of the farthest track. The blind end should be excavated on a slope of approximately ¼ horizontal to 1 vertical. Under extreme conditions the trench may be excavated entirely through the full width of the fill; this is especially desirable at the upgrade end of the fill to cut off the flow of water from the ballast and side ditches of the cut above, also in side hill fills and combina-

tion cut-fill sections. Extending rock drains entirely through the fill is undesirable in overflow territories on account of flood water flowing through the fill at the drains when the water level is higher on one side of the embankment than on the other.

The trench should be filled to the top with stones of a size easily handled by one man. Care should be taken to fill the voids on both sides and at the top of the drain with spalls to reduce to a minimum any silting and consequent settlement of the embankment.

The rock drain may be increased in capacity where necessary by installing a perforated corrugated iron pipe with perforations down on from two to four inches of permeable material, such as stone or gravel ballast, at the bottom of the drain; this is generally desirable as it gives a rapid outlet for the water, thus reducing silting and prolonging the life of the drain.

Where the topography does not permit a direct outlet for these transverse drains, an intercepting drain should be built about ten feet from the toe of slope to provide an outlet for the laterals.

(III) SPECIAL PROBLEMS DURING CONSTRUCTION

Prevention of Soft Spots and Water Pockets

1. Definitions

Soft Spot.—A small area in excavation or embankment, or the sub-soil under an embankment, saturated with water and having a relatively small supporting power (1929 Manual, page 23).

Water Pocket.—A depression in the roadbed, filled with ballast or other porous material, wherein water collects and is confined. (Vol. 16, 1915, page 596).

2. Causes

Soft spots are due to the instability of the material forming the roadbed or of the natural ground upon which the embankment is placed when saturated with water. The water may be either capillary water held in the soil by its nature or free water held there by lack of drainage or both.

Water pockets originate in construction errors of two types: (1) the failure to remove from the subgrade in cuts and the use in fills of unstable material into which the ballast is driven by the increasingly heavy loads and (2) the improper placing or dressing of stable materials, such as the use of frozen material in winter, or the deformation of the subgrade prior to ballasting. The water contained in such pockets is free water held there by lack of drainage.

3. Prevention (Vol. 20, 1919, pp. 416, 880, 1929 Manual, page 46).

Soft spots and water pockets can be prevented in many cases by proper formation of the roadbed and the use of proper kind and depth of ballast, as follows:

a. Necessary surface and sub-surface drainage facilities as specified in (I) and (II) above should be provided.

b. The roadbed should have sufficient crown to drain properly and the surface should be smooth, and be maintained in this condition until ballast is placed. Any backfilling necessary to make a smooth surface should be made of the same material as exists in the roadbed.

c. Where roadbed, in either cuts or fills, is composed of a more or less clayey material, after the work has been brought to a sub-grade all construction tracks should

be removed and the sub-grade rolled with a road roller weighing about ten tons and thus brought to proper crown and surface.

d. The operation of trains over track laid on new roadbed without ballast or sub-ballast tends to drive the ties into the roadbed and thus form depressions, which later on develop into water pockets; such operation should be avoided so far as possible.

e. Sub-ballast should be of good cinders, gravel or other similar material, so as to prevent roadbed working up into the ballast proper. Stone ballast should not be used directly on top of clay or loam roadbed.

f. Sufficient depth of ballast should be provided to insure even distribution of the load on the roadbed.

Long Cuts (Vol. 22, 1921, pp. 716, 1051, 1929 Manual, page 49).

4. If long low-grade cuts are unavoidable, they should be taken out, if practicable, to such width as will permit of wide, deep side ditches. The slopes should be made flat enough to avoid all danger of the sides of the cut sloughing. Some cuts will stand indefinitely with very steep slopes, others are not stable at 1:5 to 1. Special attention should be given to the provision of adequate intercepting ditches on the hillside above the cut.

Where it is not practicable to take care of the drainage with wide deep side ditches, sub-drainage should be provided.

Widening Cuts and Fills (Vol. 30, 1929, pp. 243, 1356, 1929 Manual, page 47).

5. When cuts and fills are to be widened and/or raised either to increase the width of roadbed for existing tracks or for the construction of additional tracks, field studies should be made to determine profile of bottom of existing ballast; the new part of the roadbed, if of an impervious nature, should be kept below the bottom of the existing ballast and sloped outward. Any additional filling needed to complete a higher roadbed section should consist of porous material.

In case porous material is not available for such higher section, lateral pipe or rock drains through the higher section will be necessary as specified in B–II.–9 and 10 above.

Multiple Tracks (Vol. 28, 1927, page 850).

6. The drainage of a roadbed carrying three or more main tracks ordinarily is not materially different from that for a single or double track line.

In cases where a system of pipe drains, consisting of mains on both sides of the roadbed with laterals extending from each under two tracks, as described in B–II.–9 above, is for any reason impracticable or insufficient, there may be used, either as a substitute or a supplement, a system of longtitudinal drains between each pair of tracks. Corrugated perforated iron pipe, 8 in. or more in diameter, should be used, laid with perforations down, on a grade of at least 0.5 per cent, with the top of the pipe at the upper end at least 12 in. below bottom of the ties. Lateral outlets of unperforated corrugated iron pipe should be used at intervals of 200 to 500 feet to take the discharge into side mains or ditches. The trench excavated between tracks to take the longitudinal drain should be backfilled with ballast.

Where no other drainage of the intertrack space is provided, it will generally be found desirable to install drainage outlets at the upgrade side of road crossings, bridge abutments and other obstructions to drainage. Corrugated iron pipe laterals serve well for this purpose.

7. **Yards** (Vol. 19, 1918, page 404, Vol. 28, 1927, page 850, 1929 Manual, page 48).

a. Since railroad yards are usually located on the flattest terrain available and have great widths of roadbed at approximately the same elevation, drainage is particularly important.

b. Drainage, therefore, should be given due consideration in the location, design and estimates of yards.

c. Where practicable, each yard should be so designed that, starting either at the middle track on flat ground or at the uphill track on sloping ground, each adjacent track in order is stepped down two to six inches, thus providing for a quick surface run-off at right angles to the tracks and a cross grade for sub-surface drainage, as well as minimizing the volume of embankment in many cases.

d. The construction of yard drainage facilities is almost always incident to other work, either the alterations of an existing yard or the construction of a new one.

e. Yards which involve drainage problems are flat-switching and gravity yards for freight cars and yards for passenger cars at terminals. The general drainage problem is met in freight yards, which are usually remote from the centers of cities. Passenger car yards, which are usually placed as near as practicable to the passenger stations, well within city limits, generally have city sewers available, which make their drainage a special problem.

f. The drainage plan for a freight yard will depend upon local conditions, including amount and distribution of rainfall, character of the soil, topography, number and grade of tracks and their position both in relation to each other and to the natural ground, and especially the location and elevation of a suitable outlet.

g. If the site is crossed by streams, consideration should be given to the construction of an intercepting channel along the entire up-stream boundary, as against building long culverts under the yard to carry the streams separately. Although the initial cost may be comparatively high, such a stream diversion shuts off all cross drainage from outside the yard, limits the yard drainage system to that required to dispose of water falling directly on the yard area, furnishes an outlet for part, if not all, of the yard drainage, and tends to bar trespassers.

h. Within the yard area, surface waters should first be taken care of as much as possible by open ditches, where they will not interfere with the safe and efficient operation of the yard.

i. Where the subgrade is of such a nature that water will pass through it, without any of it being retained, no special drainage facilities will be required if the ballast and sub-ballast are kept open and not allowed to become foul.

j. Where the sub-grade soil will hold water, special drainage facilities will be necessary. Open ditches in yard areas generally will prove to be undesirably obstructive and unsanitary. Therefore, the greater part of a yard drainage system will consist of sub-surface drains, into which surface water may be carried off the roadbed as quickly as possible.

k. A yard drainage system should be as nearly as possible a permanent facility. There is no economy in using debatable materials and workmanship. The design, particularly as to waterway capacities, should be made with due consideration of the probability of future extensions of the yard and consequently of the drainage system. The design should permit thorough inspection, cleaning and flushing and protection of inlets and outlets.

l. In the case of the reconstruction of or additions to existing yards, the existing drains, although adequate for existing facilities, may be unsuitable in elevation, grade or capacity for the new layout; a new and independent system for the new layout will then be necessary.

m. The design of the sub-surface system should be based on the available drainage outlets, building up the profile of the drains on grades and to elevations suitable for proper drainage; or, if this is not feasible, the deepening of the outlets must be considered.

n. Ordinarily one or more main drains should be laid parallel with and in spaces between the tracks. The detailed specifications for pipe drains given in B–II.–9 above should be observed.

o. Cross-drains should be so located that all car retarders, switch layouts, signal facilities, towers, scales, etc. may have suitable inlets and all parts of the yard may be drained by catch-basins between tracks. Breaks in the track grade are danger lines, even where the change is slight. Water will drain from the steeper grade and collect at the point of change, unless catch-basins are provided there to carry it away.

It is of advantage to lay cross drains at right angles to the tracks. Diagonal trenches are awkward and expensive to excavate under tracks and the drains are expensive to maintain; a diagonal system should be used only when the proper grade cannot otherwise be obtained economically.

p. On yard construction particularly it is economically important that the drainage system be installed where practicable before the grading and track work is begun.

q. If the subsoil is of such a consistency as to quickly fill up a pipe drain, rock drains, as described in B–II.–10 above, may be installed between tracks with pipe drains leading off to natural drainage.

8. Passenger Stations

Light track grades, platforms, water cranes and ballast fouled by collected dirt and sweepings, all tend to make necessary special drainage at passenger stations.

Perforated iron pipe, with catch-basins and laterals at frequent intervals, should be laid in trenches located between the ends of the ties and the edge of the platform; or a drain pipe may be laid between tracks at a sufficient depth to be below frost and movement of the soil. These drains should be connected by cross drains and ditches to suitable outlets. All trenches should be backfilled with a selected permeable material, such as clean crushed stone or washed gravel.

9. Highway Grade Crossings

At crossings where the railroad is on embankment, perforated corrugated iron pipes should be laid in a 3-foot trench excavated at the outside ends of ties on single and double track crossings (and also between each pair of tracks on multiple track crossings) at a depth of not less than 4 feet below bottom of ties and extending not less than fifty feet each way from the crossing; the pipes should be on a heavy grade not less than 3%; at the lower end of the outside pipes a bend should be used to connect with unperforated pipe leading down the slope to the side ditches. The trench should be backfilled with one-man stone capped with a layer of crushed stone or washed gravel.

Where the railroad is in cut, the installation should be substantially the same, except that the depth of the pipe will be determined by the elevation of the bottom of the side ditches and the trench should be filled with crushed stone or washed gravel.

This and previous reports cover the subjects in the outline down to

(C) Recommended Practice on Maintenance

Much of the material in the present report is a revision of the following material in the 1929 Manual which it will replace:

pp. 46, 47. Means for prevention or cure of water pockets in roadbed, Sections (7) and (8).

pp. 47, 48. Methods of Preventing the Formation of Water Pockets under the Ballast when Embankments are widened and/or raised.

p. 48. Drainage of Roadway through Stations and Yards.
p. 49. Drainage of Large Cuts, Paragraphs (2) and (3).

The Committee recommends that the subject "Roadbed Drainage" be continued.

Appendix C

(3) STUDY OF THE SERVICE LIFE OF FENCE WIRE AND SPECIFICATIONS FOR RAILWAY FENCE WIRE

W. C. Pruett, Chairman, Sub-Committee; J. B. Arter, T. A. Burgess, L. C. Frohman, G. F. Hamilton, H. H. Harman, W. J. Lank, H. N. White, F. E. Wiesner.

This subject in some form or other has been under consideration by the Association for the past several years. While your Committee, this year, has assembled some additional data and made some studies of tests that are under way, it is not yet ready to make any final recommendations.

Some information is at hand on several tests that are being conducted on the service life of fence wire. An interesting one is that installed during August, 1925, by the Kansas City Southern in the coastal plains territory near Beaumont, Texas, where ordinary wire corrodes quickly from the salt atmosphere. Three grades of barbed wire are being used: (1) Ordinary galvanized wire, (2) extra heavy galvanized wire, and (3) a special galvanized wire. This test includes fence post as well as wire, and it was so installed as to place a part of each grade of wire under water. Tests (1) and (3) began to show signs of rust on the barbs above the water and on all of the wire under waters as early as 1928. The inspection made in July, 1932, seven years after installation, showed all of the three grades of wire above water as being slightly rusty, and all the wires under the water as very rusty; but not yet sufficient difference to determine the exact merits of each class. It is hoped that more information may be had from this test later.

Information was received of several fence installations made many years ago that have clearly demonstrated more resistance to corrosion than most of the wire manufactured in recent years. One example is that of some barbed wire on the Bushman farm near Milledgeville, Ill. which was installed in 1886, and after 46 years is still in service. This old wire, and possibly others that are being studied, is made of pure wrought iron. Such a record would indicate that where structural strength is not an important factor, it might be advantageous to go back to the use of the older materials and methods in making fence wire.

Chemical analyses of some barbed wires that are not of pure wrought iron but which have been in service an unusual number of years, have been made for the Committee by the laboratories of the Bethlehem Steel Company and the Inland Steel Company. Results of these analyses are as follows:

	C.	*Mn.*	*P.*	*S.*	*Si.*	*Cu.*
Sample 1–M F.E.C. Ry. installed 1902—Florida, near the coast. Condition—still in service, but very thin and rusted entirely through in two places...........	.07	.41	.098	.104	.01	.18
Sample 2–M F.E.C. Ry. installed 1902—Florida, near the coast. Condition—just slightly better than that of sample 1–M	.08	.43	.108	.075	.01	.01
Sample No. 1 M.K.T. RR. installed 1900—Northern Oklahoma. Condition—Completely rusted out and replaced in 1931	.12	.61	.094	.096		
Sample No. 2—John Atkins farm installed 1902—Near Denison in North Texas. Condition—Full section and good for at least another 10 years of service......	.12	.52	.099	.057		

The names of the manufacturers of this wire, and the kind of protective coating, if any, are not known. The wire from which sample No. 2 was taken is in much better physical condition than any of the others. But this particular wire was in a location where it was not subject to salt atmosphere, nor to damaging effects from right-of-way fires, and is several miles remote from industrial plants' smoke and gases; this no doubt accounts to some extent for its present good condition. The next best of these four is that wire from which sample 2–M was taken. This is from the top strand of a fence through a salt marsh on mile 154 of the Florida East Coast Railway, where the salt atmosphere is very damaging to metal. After 30 years of service under this adverse condition, it is badly pitted and corroded but still retains considerable strength and the barbs are in good condition. The wire of sample 1–M is in such condition as to warrant replacement soon; and that of sample No. 1 has already been replaced.

The Committee feels that these analyses are not sufficient in themselves for any definite conclusions; but they, with other information on hand, do further emphasize some of the findings of the U.S. Department of Agriculture in their study of the Corrosion of Fence Wire a number of years ago, and published in Farmers' Bulletin 239. That part of this study which deals with electrolysis and its effect on wire, is bearing so closely upon the matter under investigation, that the Committee feels justified in quoting a part of it here:

"There is, however, a very great variability in the way different irons rust. One will cover itself over with a superficial layer of oxide, which will then act as a coating protecting the metal for many years, while another will pit so badly that the corrosion eats to the heart of the metal in a short time. Samples of wrought iron cut nails that had been exposed to the weather for forty years were sent to the laboratory and found to be in as good condition as the day they were bought, while samples of steel wire four years old, which were originally galvanized, have been received which were pitted to the breaking point. The problem, therefore, is not to find a kind of iron that will not rust, but to determine the causes which lead to the kind of rusting which makes wire shortlived, whether it is furnished with a protective coating or not; and further than this, to see if there is not some way in which we may eventually be in a position to insist upon specifications for steel wire that will be reasonably resistant.

"Wire that is hung in the field is in just the condition to suffer from electrolysis if the metal is not perfectly homogeneous in structure; that is to say if the manganese and other impurities are not perfectly distributed throughout the metal. All rain water contains small amounts of salt dissolved from the dust in the air, and is therefore a conductor of electricity. Water collected during a thundershower is particularly rich in substances that conduct electricity, and the sparking of the lightning through the moist air forms small quantities of nitric acid, and acids conduct electrical currents even better than salt solutions. A moment's thought will show that under the conditions cited we have all the elements present to cause electrolysis to take place. Differences of potential will occur in the wire, local circuits will be established through the wires or through the wires and ground, and current will flow. Just as in the case of the bell battery these currents can only be generated at the expense of something, and in this case it is the iron if it is not the zinc of the galvanized covering. This explanation is capable of accounting for the deep pitting observed in the corrosion of many wires, this pitting being characteristic of electrolytic action. It also accounts for the much more rapid corrosion of wire near the seashore, as the rain water in such locality contains more salt and thus this action is hastened."

Recommendations

The Committee does not feel that they have made sufficient study to submit any definite specifications at this time. This report is offered as information only, and it is recommended that the subject be reassigned for the succeeding year.

Appendix D

(4) INVESTIGATE THE USE OF PORTABLE CRIBBING IN PLACE OF RIGID RETAINING WALLS AND THE UTILITY OF THE DIFFERENT KINDS OF CRIBBING

A. E. Botts, Chairman, Sub-Committee; J. B. Arter, H. B. Barry, L. J. Drumeller, J. N. Grim, R. M. Jolley, W. A. Murray, J. A. Noble, Roscoe Owen, and W. C. Swartout.

Your Committee, through its various members, has attempted to establish facts pertinent to the above subject and presents the following report as information with the recommendation that the subject be discontinued:

Definitions

CRIB WALL.—A retaining wall consisting of a series of cells (cribs) formed by interlaced or inter-connected longitudinal and transverse members and filled with earth or other filling material.

CRIBBING.—The members constituting a crib.

STRETCHER.—A longitudinal member of a crib.

HEADER.—A transverse member of a crib.

Materials

Cribbing is available in three materials: timber, reinforced concrete and galvanized sheet iron.

TIMBER has been used on railroads for many years in crib walls. Generally the timber used has been "second-hand" and the crib wall temporary or unimportant. One railroad, which has its own treating plant, makes a practice of using treated cull cross-ties and dimension lumber for all crib work, except in cities where a better appearing wall is required. These timber cribs are lower in first cost than other types of cribbing and have a service life of twenty or more years.

PRECAST REINFORCED CONCRETE CRIBBING dates back prior to 1915 and its use is gradually increasing. There are a number of different types of concrete cribbing on the market. Each manufacturer has his own design; units made by one are not interchangeable with those made by another. Most manufacturers make both open and closed face cribbing. (See Fig. 1 to 5 for illustrations of open and closed face types of various manufacturers.)

CRIBBING FABRICATED FROM SHEET INGOT IRON GALVANIZED has recently been placed on the market for both open and closed face types of crib walls. The members are composed of 16 gage metal with reinforcements of 16 to 9 gage. (See Fig. 10, which shows this cribbing for both open and closed face crib walls in use.) This is a new and novel departure in cribbing material. The manufacturers claim for it great strength, long life (based on experience with the same material in culverts), and cheapness. Only service tests will prove the qualifications of this thin metal in contact with earth.

At the present time the principal material used for cribbing is reinforced concrete. The balance of this report will be restricted to a consideration of crib walls of that material.

ACTUAL INSTALLATIONS

Information as to actual installations, costs, advantages, etc., has been secured from engineering officers of various railroads and from the various manufacturers of cribbing.

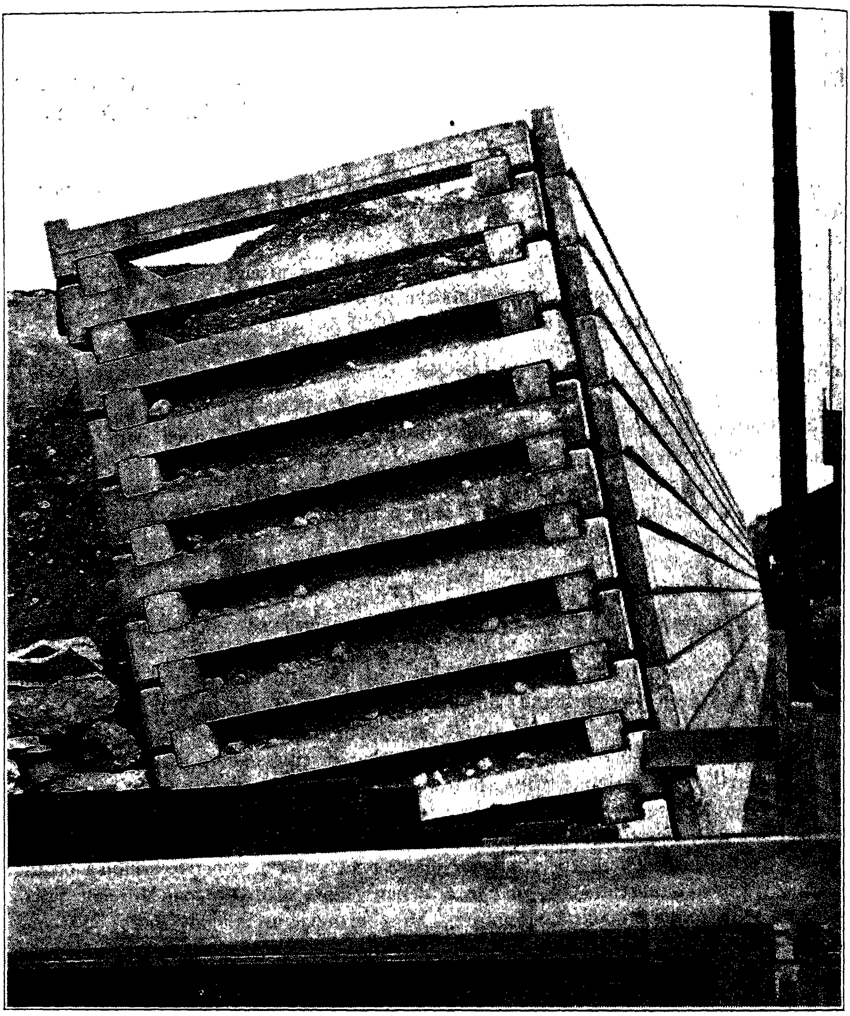


FIG. 1.

There are records of walls up to 1506 ft. (DL&W Jersey City 1929, height 6 ft. 10 in. to 18 ft. 10 in.) in length. Some of these walls attained a maximum height of 28.5 ft. The usual heights are between 7 and 12 ft.

Walls have been installed with batter varying from 1:24 to 4½:10; in general, the higher the wall, the greater the batter. This appears to have been influenced in some cases by the space available, the batter being lessened to fit the wall into the space available.

In most instances, the material retained is earth embankment with or without a surcharge of from 2 to 10 ft. (see Fig. 2 and 6) carrying a track whose center line is from 8 to 15 ft. from the face of the wall. Occasionally crib walls have been used to

prevent the encroachment of highway fills on railroad right-of-way or tracks. In one case (Fig. 7) a street was widened; the additional width is carried on a crib wall built up in front of an existing solid masonry wall, which is covered by earth filling in the cribs.

Crib walls are generally founded directly on the ground with a minimum of excavation. Occasionally where the foundation conditions are particularly unstable, cribs have been placed on special concrete blocks placed perpendicular to the face of the wall.

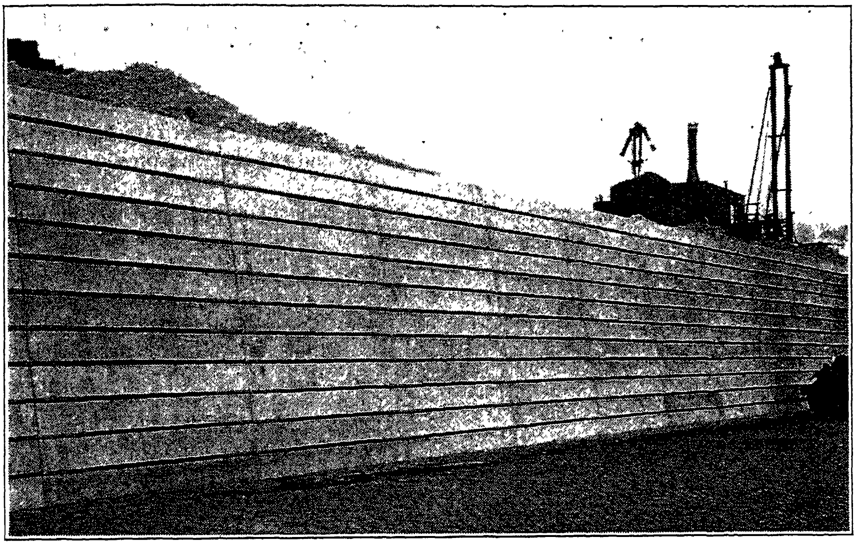


FIG. 2.

The omission of special foundation is the principal reason why crib walls, where adaptable, are generally cheaper than a poured-in-place gravity wall to serve the same purpose. Some typical installations, with principal dimensions, cost and, where available, estimated cost of solid wall for the same location, are listed in the following table:

Item	*Class*	*Length*	*Min. Height*	*Max. Height*	*Av. Height*	*Facial Area Sq. Ft.*	*Total Cost*	*Cost Per Sq. Ft. Face Area*	*Estimated Total Cost Monolithic Wall For Same Location*	*Year Built*
1	Open	96′	4′3″	8′0″	7.06	678	1288.*	1.90	1191.†	1931
2	"	192′	4′0″	20′8″	13.10	2515	6288.	2.49	15000.	1925
3	"	160′	25′6″	28′6″	27.30	4368	12034.	2.76	...	1924
4	"	434′	5′0″	7′4″	6.00	2604	8692.	3.33	11458.	1928
5	"	120′	5′0″	24′0″	15.00	1800	6768	3.75	....	1930
6	"	422′	5′0″	10′0″	7.92	3340	8259	2.47	13450.	1924
7	Closed	541′	5′0″	7′0″	6.25	3380	8571.	2.54	...	1930
			Average cost per sq. ft.					2.78		

* Estimated cost.
† Actual cost.

While the average cost of the crib walls reported in this table is $2.78 per sq. ft. of facial area, the actual costs vary considerably from this. The amount and character of

excavation and the height of the wall have very marked effects on the cost per sq. ft. of facial area.

The estimates shown for solid walls indicate that the cost of a solid wall for a given location may be from 1.3 to 2.3 times the cost of a crib wall. In other cases, as in item "1", the cost of a crib wall may be greater than a solid wall.

Failures

Of the numerous installations of portable cribbing reported, only two installations are reported as having failed. In one case (a wall built in 1922, 232 feet long, of which 112 ft. was 12 ft. high and 120 ft.—7 ft. 6 in. high) the upper part of the wall, 12 ft. high, failed in 1923. Fig. 8 and 9 show this wall when completed in 1922 and as of January 1, 1929. This failure was attributed to (1) weakness of design, (2) character of material (granulated slag and cinders) used for filling and (3) excessive pressure due to surcharge and character of material involved.

Another wall, which failed on account of shallow foundation, improper backfill, and surcharge, had to be torn down and rebuilt.

Advantages

Concrete crib walls have the following advantages over monolithic concrete walls:

1. They can be constructed in a restricted area without encroachment on adjoining property.

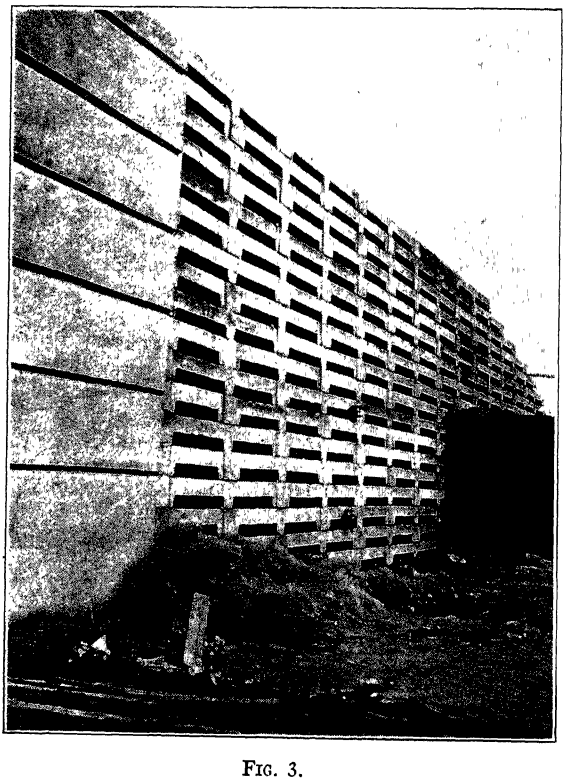


Fig. 3.

2. They can be placed on foundation soils which would require piles or caissons under heavy mass walls. A slight settlement of foundation soil does not injure a properly designed and erected crib wall.

3. They provide for drainage without the use of drain pipes and sewer connections.

4. No forms, special equipment, nor skilled labor is required in their erection.

5. They require a minimum amount of foundation excavation; under ordinary conditions the removal of the top soil to a depth of one foot is sufficient.

6. No foundation masonry is required.

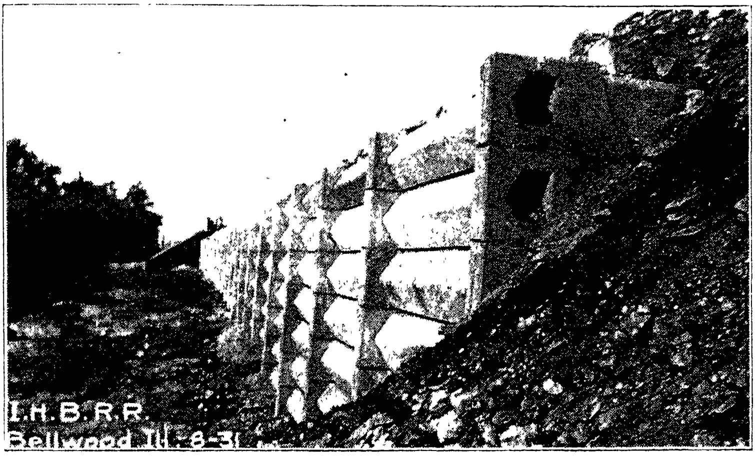


FIG. 4.

7. They can be built in short sections, one or two cribs or cells at a time, the excavation being used as fill (where suitable) in the preceding crib. This reduces to a minimum the amount of shoring and false work required and the consequent interference with traffic.

8. These advantages collectively result in greater speed of erection and

9. Generally lower cost.

10. The embankment can be placed and the wall loaded immediately upon completion. Concrete poured in place requires time for curing.

11. Standardized precast units may be carried in stock for use in emergency.

12. The units may be salvaged upon the removal of a wall and re-used elsewhere.

13. A slight increase in the height of a wall may be made readily to take care of a minor bank widening or grade raise.

Disadvantages

Offsetting these advantages are certain disadvantages which tend to restrict the use of crib walls. These may be stated generally as follows:

1. The crib members are not designed to carry the direct load of a train; the top sections of crib wall must therefore be kept out from under the ties. For low walls this generally requires the use of more right-of-way than a solid wall, of which the base may project under the track and the top is narrower.

2. The lack of a firm foundation may result in settlement and lateral movement which, if uneven, destroys the alignment either horizontally or longitudinally or both, with consequent injury to the appearance and possibly to the stability of the wall.

3. Drainage through the face might be unsightly and, if the wall is on a property line, may be objectionable to the adjoining owner.

4. The small cross-section of the members makes it imperative that the concrete be of the most durable quality, which is difficult to obtain, and that the reinforcing steel be carefully placed, so as not to be too close to the surface.

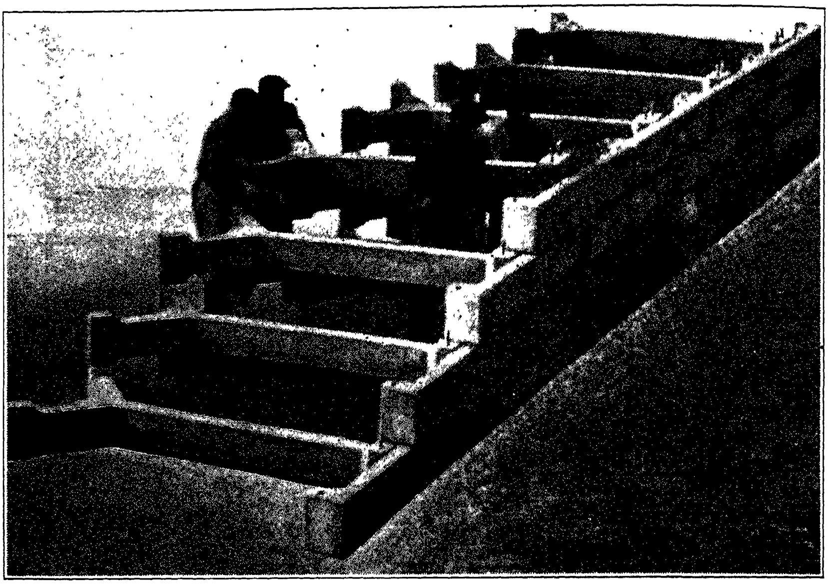


FIG. 5.

Recommendations

USE: Consideration of the advantages and disadvantages of concrete crib walls determines that there are many cases where their use is justified. Most of these cases will fall in one of the following classes:

1. Temporary walls during construction, where conditions are such that the wall must or can be salvaged. Where a temporary wall must be left in place buried in a fill, cribs made of old ties will ordinarily be most economical.

2. Walls where there is uncertainty as to their permanency, as for example,

a. Retaining walls where additional tracks may be added in the future but where the necessary land has not yet been acquired.

b. Retaining walls where the adjoining land has not been improved and where the character of that improvement is uncertain. For example, the adjoining land may in the future be occupied by a building with a basement, in which case the railroad retaining wall, at least in some states, must be carried below the basement level; or the future development may be at ground level, with a retaining wall supporting only the added fill, or it may be at track level with no retaining wall at all required in the future. In such a case, the immediate solution may be to use a crib wall supporting only the fill.

c. Wing walls of bridge abutments along highways, where the abutments may be extended in the future to accommodate additional tracks.

The use of concrete crib walls in such cases permits changes to suit future conditions to be made with a minimum loss.

3. Walls in permanent locations on restricted right-of-way where encroachment on adjoining property during construction is not permissible.

4. Walls in permanent locations on poor foundation soils, where the necessity for absolute stability and true alignment and grade are not such as to warrant the additional cost of walls with proper foundations.

5. Walls in permanent locations where traffic must be maintained with the minimum interference and where the necessity for absolute stability and true alignment and grade are not such as to warrant the additional cost of falsework and foundations; these cases occur generally in terminal and industrial districts.

6. Minor installations, such as where the roadbed is to be widened around switch stands and signal foundations.

Wall Design

Like all properly constructed retaining walls, crib walls should be designed to meet local conditions such as:

1. The character of the foundation soil.
2. The height and character of the bank to be retained, the height of slope and character of surcharged fill and the amount and distribution of surcharged concentrated loads.
3. The nature of the material available for filling the cells of the crib.

A crib wall is essentially an elastic structure and should be free to move in any direction to adjust itself to reasonable settlement and thrust movement without structural failure.

Essential features of wall design are as follows:

1. The crib wall should be stable as a whole against overturning.
2. The bearing area of the bottom stretchers on the ground should be sufficient.
3. The crib should be designed so that no direct track load comes on any member; such loads will crush or break the headers and back stretchers in the upper sections.

The following general specifications are recommended:

1. The width of the crib wall at top and bottom should not be less than 4 feet.
2. The width at the base should not be less than one-half the height.
3. The front batter should not be less than 1 horizontal: 6 vertical.
4. The openings between stretchers in the face should have such a relation to the horizontal width of the stretchers that the filling material will not spill out.
5. Headers should be spaced not more than 6 feet center to center.
6. The front and rear walls of the cribs should be connected together continuously.
7. All corners should be satisfactorily anchored and braced.
8. Free joints should extend clear through the crib wall approximately every 100 feet.

Unit Design

The units should be of sufficient size and strength to resist bending, shear and bearing in service and breakage in handling.

Their size and weight should be such that they can be handled and placed without special equipment. The concrete and reinforcing steel should conform to the A.R.E.A. specifications for 3500 lb. unit stress concrete. All reinforcing steel should be so located that it will be protected by at least ¾ in. of concrete, preferably 1 in.

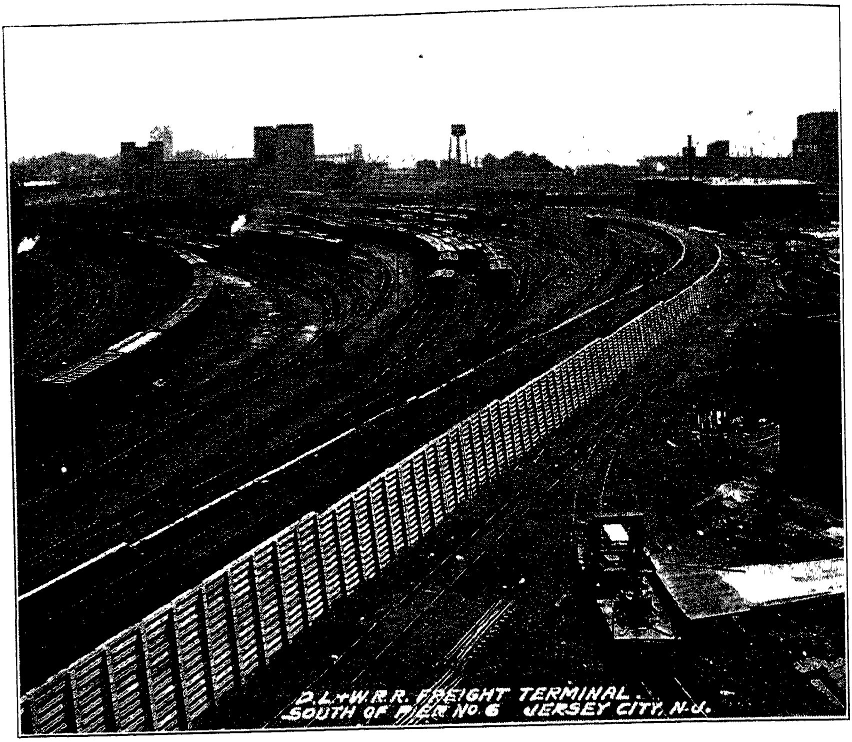


FIG. 6.

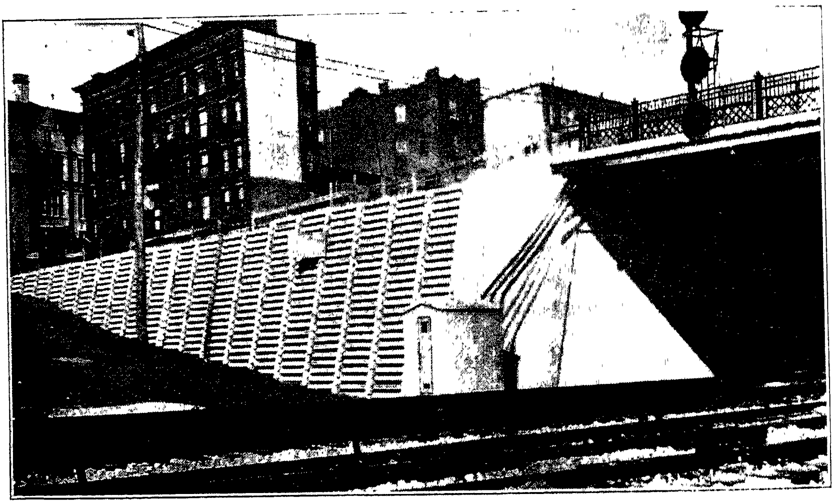


FIG. 7.

Unit Manufacture

Durability, or the inherent quality of concrete to withstand exposure conditions, is a most important feature in reinforced concrete cribbing and cannot be stressed too much.

Factors which vitally affect durability are the selection, grading and proportioning of the aggregates, the quality of the cement, the methods of making, and the methods and time of curing.

The better knowledge of basic principles of making concrete in recent years should result in a trend for the better in the elimination of deterioration or disintegration. The producers of factory made concrete products must realize that concrete is a treacherous material to deal with when reputations are at stake; their interest in the best possible production should prompt them to eliminate all causes of trouble insofar as it is humanly possible to do so in the light of their best knowledge.

In the manufacture of cribbing, particular care must be taken to secure a smooth dense surface finish without plastering. All edges and corners should be beveled. The units should be carefully cured and not shipped until the concrete has reached a unit strength of 3000 lb. as determined by cylinders made and cured under the same conditions as the cribbing. Loading, unloading and stacking should be carefully done to prevent damage.

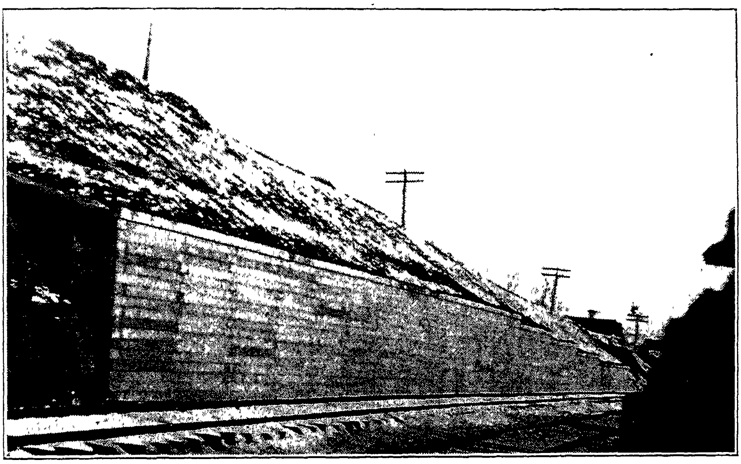


FIG. 8.

Backfilling

The material used for backfilling should consist of crushed stone, gravel, or other approved permeable material, which contains no ingredient injurious to concrete. Clay, loam or fine sand should not be permitted within 2 feet of the face.

Comparison of Different Types

In comparing different designs of cribbing, consideration should be given to other things than the cost of the units, as follows:

1. The number of units required.
2. The size and weight of the units.

These influence the erection cost.

3. The quantity of concrete per square foot of facial area is a measure of the strength and stability of a wall.

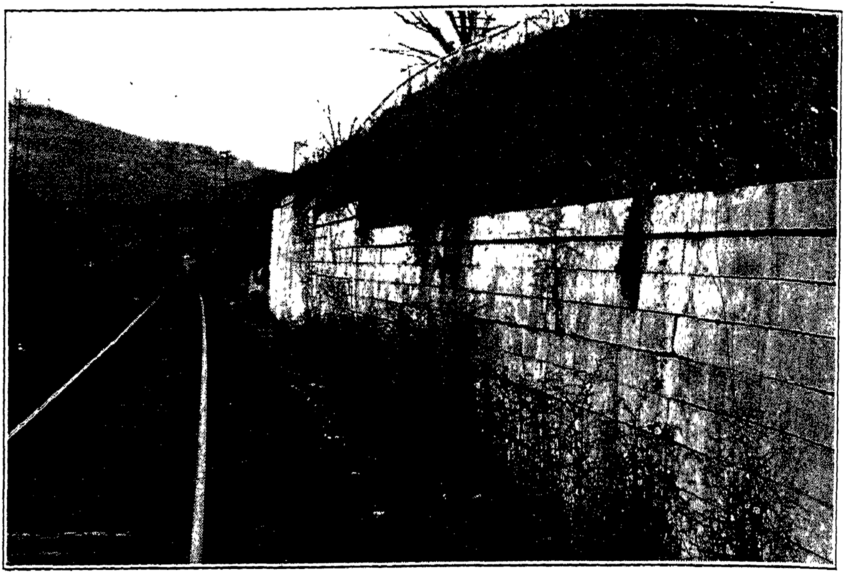


Fig. 9.

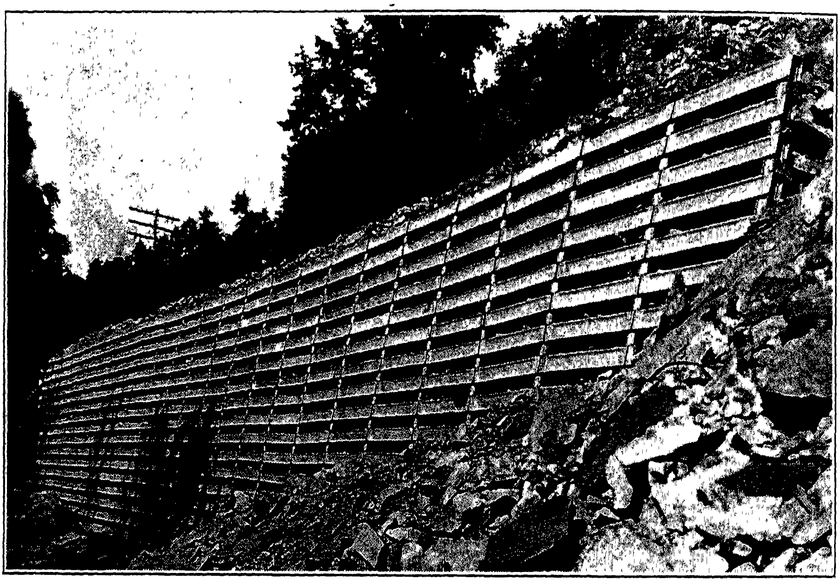


Fig. 10.

Appendix E

(5) PHYSICAL PROPERTIES OF SOILS AND THEIR EFFECT ON ROADBED PERFORMANCES

H. W. Legro, Chairman, Sub-Committee; J. B. Akers, G. H. Burnette, Paul Chipman, L. C. Frohman, G. E. Ladd, E. R. Lewis, Roscoe Owen, L. S. Rose, W. C. Swartout, J. B. Trenholm.

Improved design of the track structure—ballast, ties, rail and joints—has been continuous and reasonably in pace with the demands of progressively heavier loads and higher speeds of railroad operation. Experience and research have added much to knowledge of the effects these elements of the track structure have on economical operation and maintenance. The action of water as an enemy of track has long been recognized and drainage methods to prevent free water entering or remaining in and under ballast have been devised and used extensively.

The portion of the roadbed upon which the ballast is placed, which must support the static load of the track and the heavy transmitted loads at impact of rolling equipment has, however, been studied in relatively small degree. The soil of the roadbed has been but broadly classified as to its observed action under railroad operation and climatic forces.

As an adequate foundation of a building or a bridge is necessary to support the superstructure and other loads, of comparable importance to the track structure is the subgrade—its character and condition. Unless subgrade material is stable within limits under load and climatic conditions, its effectiveness as a foundation is known to be lessened with consequent impairment of the proper functions of the ballast, ties, rail and joints. It is a matter of practical experience that subgrade of quality or condition generally recognized as subnormal causes excessive maintenance expense, or if extra-maintenance be deferred, more rapid deterioration of track with adverse effect on riding qualities, train schedules and condition of rolling equipment.

As often stated, there is a dearth of accurate knowledge of the physical characteristics of soils upon which may be based intelligent selection and rejection, correction of adverse conditions by economical means and utilization of the maximum possibilities of the material at hand.

An increasing number of investigators are engaged in field observations and laboratory experiments to add to the practical science of soil physics. Not to attempt a list of these endeavors, the works of the U.S. Bureau of Soils, the U.S. Bureau of Public Roads, the highway departments of several states, Massachusetts Institute of Technology, Dr. Karl Terzaghi (Technische Hochschule, Vienna), and Prof. D. P. Krynine (Yale University), are notable instances.

These contemporaneous studies are being made in various engineering fields of which foundations, dams and highways are representative. Any of these lines of inquiry may discover some facts of basic or incidental interest in other fields. At present the recorded results, even in the same field, are far from co-ordinated. In the field of railroad subgrade studies, where many influences are unlike those of any other, interpretation of other studies must take into account the peculiar conditions.

The Committee is undertaking a review of available data on the physical characteristics of soils as found in natural deposits and as disturbed from their natural position to form embankments and will endeavor to simplify as far as possible information on the behavior of various soil masses under the influences of pressure, moisture content and frost heaving.

Including this consideration of soil characteristics and proceeding to subsequent stages of investigation and report, the subject assigned requires development in accordance with the following outline:

(1) Characteristics of soils.
(2) Functions of subgrade soils.
(3) Test methods.
(4) Effects of various subgrade soils on the track structure.
(5) Roadbed requirements.

Recommendation

This report is offered as information, with the recommendation that the subject be continued.

Appendix F

(6) DRAINAGE AREAS AND WATER RUN-OFF AND THE PROPER SIZE OF WATERWAY OPENINGS

Jamison Vawter, Chairman, Sub-Committee; W. G. Brown, J. A. Given, Daniel Hillman, G. E. Ladd, E. R. Lewis, J. C. Nickerson, J. A. Noble, C. S. Sample, Thomas Walker.

In the 1930 report of the Roadway Committee on this subject (Proc., Vol. 31, pp. 625–640) a rather thorough discussion was made which included information and formulas taken from previous studies of the Committee which were published in the Proceedings in 1909 and 1911 (Vol. 10, part 2, pp. 967–1022 and Vol. 12, part 3, pp. 482–519). The Dun Table for Missouri and Kansas, with percentages applicable to Illinois, Oklahoma, Texas and New Mexico, is given in Vol. 10, page 977 and Vol. 12, page 485. Data for 447 streams in the United States are also given in Vol. 12, pp. 505–519.

It is not considered desirable to take the space to reprint data which are in previous volumes of the Proceedings and accordingly this report consists of two additional formulas which appear in recent publications together with additional conclusions of the Committee based on further study. Additional references are given to supplement those published in 1930.

ADDITIONAL FORMULAS

The Fuller Formula.[1]

[1] FLOOD FLOWS by W. E. Fuller, Trans. A.S.C.E., Vol. 77 (1914), pp. 564–694.

$$Q = C A^{0.8} (1 + 0.8 \log T)$$
$$Q \text{ (max.)} = Q (1 + 2A^{-0.3}).$$
$$Q \text{ (av.)} = C A^{0.8})$$

where Q = largest 24 hour average rate of flow to be expected in a period of T years.

Q (max.) = maximum rate of flow to be expected under same conditions.

Q (av.) = average yearly flood (obtained from maximum 24 hour average flood for each year) in cu. ft. per sec.

C = a coefficient which is constant for the stream at the observation point.

A = drainage area in square miles.

The method recommended for obtaining C is by dividing the value of Q (av.) (obtained by observations over a number of years by $A^{0.8}$. An approximate value may be obtained from only 5 or 6 years continuous observations.

This formula is based largely on observations on streams on the Eastern Coast. It is claimed to give general satisfaction throughout the greater portion of the United States except the arid and semi-arid portion of the Middle and Southwest. In a discussion of this paper by Mr. Hazen, a map is shown giving values for C for various parts of the United States.

The Jarvis Formula[2]

[2] FLOOD FLOW CHARACTERISTICS by C. S. Jarvis, Trans. A.S.C.E., Vol. 89 (1926), pp. 985–1104.

$$Q = 10{,}000\, M^{0.5}$$

where $Q =$ the maximum discharge in cu. ft. per sec.

$M =$ drainage area in square miles.

The above formula is a modified Myers formula. The coefficient given above is called the 100 per cent value and each stream is to be given a percentage rating.

$$Q = 100\, M^{0.5}$$

being used for a stream with a rating of 1 per cent.

A valuable part of the paper by Mr. Jarvis is a table in which data are given for 1019 stations on streams in North America and Hawaii and 44 Foreign. The table gives the location, maximum run-off in second-feet per sq. mile and date, expected peaks—both frequent and rare (not given in all cases), and percentage rating on the Myers scale. The stations are arranged in order of the sizes of the drainage areas, starting with 0.17 sq. miles and ending with 1,400,000 sq. miles for the American streams.

In closing the discussion, Mr. Jarvis included a map of the United States on which was shown percentages on the Myers scale for various streams.

OTHER SOURCES OF INFORMATION

A carefully prepared bibliography was given in the 1930 report of this Committee; the following references may be added to the ones in that report.

FLOOD FLOWS—Allen Hazen, John Wiley & Sons, 1930.

RUN-OFF—RATIONAL RUN-OFF FORMULAS—R. L. Gregory and C. E. Arnold, Pro., A.S.C.E., April, 1931, pp. 561–622.

Conclusions

Although previous reports of the Committee have contained a warning against the blind use of formulas, it is felt that it should be repeated here. The computation of run-off and waterway openings will always require the best judgment of experienced engineers giving attention to all information available, particularly local conditions, including attention to the size and behavior of other openings in the vicinity carrying the same or similar streams. The use of a formula in the absence of general detailed information is warranted when it is known to fit local conditions.

The same formula cannot be expected to give satisfactory results for both large and small drainage areas.

The Dun data, when expressed in the form of an exponential equation, have an exponent from about one for small areas to about one-half for large ones. It, therefore, cannot be considered in the category of a single definite formula. The Dun data have apparently given satisfactory results for the part of the country which they cover. The Committee believes that data of this nature are of more value than reliance on a given formula.

For large streams, when observations cover a number of years, the Fuller formula should give satisfactory results for the Eastern and Western parts of the country. In the Middle and Southwest, the modified Myers formula as given by Jarvis should be more satisfactory if sufficient information is known to give the stream its proper percentage rating.

The "rational method" of computing run-off is to be recommended in the design of storm sewers but is of doubtful value in computing waterway openings for other water-sheds. It can be of little value in any drainage area which contains more than one storm area.

Recommendations

The Committee believes that tables similar to the Dun data can best be compiled by the separate railroad companies for their own use, making use of all experience gained in the territory served by them. Attempts made to obtain these data by means of a questionnaire sent to the various roads have not proved successful.

The Committee recommends the report be accepted as information.

Appendix G

(7) METHODS OF CORRECTING SOFT SPOTS IN RAILWAY ROADBED WHERE IT IS IMPRACTICABLE TO STABILIZE IT BY DRAINAGE

O. H. Wainscott, Chairman, Sub-Committee; W. G. Brown, T. A. Burgess, L. J. Drumeller, Daniel Hillman, W. F. Monahan, J. C. Nickerson, Thomas Walker, F. E. Wiesner.

To avoid conflicting with the work of Sub-Committee 2—Roadbed Drainage—this Sub-Committee has avoided making any mention of drainage in this report; however, there are certain conditions existing in roadbeds where soft spots and slides exist due to presence of water, but cannot be corrected by drainage due to the fact that the unstable material in the fill distorts the drains and fills in the voids so that the tile lines become blocked and inefficient, making it necessary in the end to use other remedies.

Scope

The scope of this subject is so great, covering widely different physical, climatic and traffic conditions, that the Committee has attempted to deal with it only in a general way and give cases of actual experience and practical remedies. There are certain general conditions which apply to all cases, but the method of treating each individual case differs for various railroads and also for various parts of the country. This makes it necessary to investigate each soft spot, water pocket or slide and analyze the surrounding conditions in order to arrive at the proper method of curing the particular trouble.

Importance

The problem of eliminating soft spots, water pockets and slides has become more pressing in recent years following the increase of traffic volume and speed of trains with heavier locomotives and equipment, and it is necessary to develop some economical and successful methods for the permanent cure of such conditions when the same cannot be corrected by drainage.

Causes

Unstable roadbed conditions are found to be especially troublesome where the material consists of soil known as gumbo, buckshot clay, post-oak clay and red clay mixed with quicksand; when tracks are constructed across swampy territory where there are a number of sinkholes or along a hillside of rock with a slope of approximately 45 degrees overlaid with clay or other material of poor supporting power, and embankments built partially of material obtained from borrow pits and completed by hauling in dirt.

Troubles in cuts may be due to narrow roadbed, steep cut slopes and unstable materials either in the cut or below subgrade.

The cause of unstable roadbed can be summed up as follows:

a. Embankment made of unstable material,
b. Roadbed built on sloping or otherwise unsuitable surface,
c. Embankments made during winter by use of frozen material,
d. Construction of fills on material having insufficient bearing power to carry the load,
e. Cuts made through unstable strata,
f. Defective construction,
g. Improper first ballast on new fill.

Remedies

The study of means for improving conditions caused by soft spots in railway roadbed shows that on a number of railways the cause has not been investigated until the situation became very troublesome. A remedy has then been applied where the expenditure for such remedial measures has been justified by the saving in maintenance expense.

Description of treatments other than drainage which have proved successful in overcoming poor track conditions resulting from soft spots, water pockets and slides, follows:

A.

(1) Burning Spines

A series of longitudinal and cross trenches were dug on the slope of a sliding bank. Trenches were filled with old ties, pile heads and timbers and a covering of clay was placed over same. Timbers were fired and smouldered for several weeks. Clay was added periodically to maintain the approximate plane of the original slope. A brick-like mass resulted which prevented further sliding of the embankment.

(2) Rebuild Fills

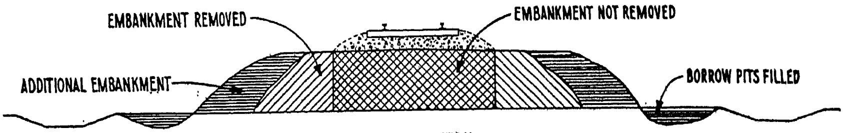
Satisfactory results have been obtained by the removal of all or a part of the unstable material and the replacement of the same with material known to be of good quality.

PLAN "A"

Line the track over as close as practicable to one shoulder. Excavate as much as can be removed safely from the opposite side, replace with good material. Line track over to near the shoulder treated and repeat process on the opposite side. Line the track to center and widen the roadbed, giving a good lift on new ballast. Excavated materials to be placed so as to weight the toe of the slope and fill old borrow pits. Construct new ditch near the edge of the right-of-way.

PLAN "B"

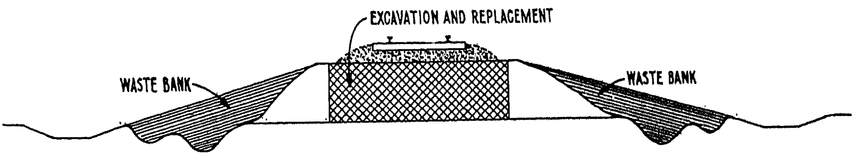
Divert the track, excavate about twelve feet of the central portion of the embankment to approximately the original ground level and backfill with good material. Restore track to its original alignment. Excavated materials to be used to flatten the slopes and fill old borrow pits. Re-ballast track and construct new ditches near the edge of the right-of-way.



TYPICAL SECTION

PLAN "C"

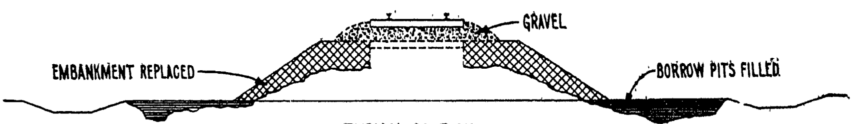
Spread the embankment with a spreader fully lowered, cut the shoulder to maximum depth below bottom of tie. Make old base of rail new sub-grade and complete fill with good material. Re-ballast the track and construct new ditches near the edge of the right-of-way.



TYPICAL SECTION

PLAN "D"

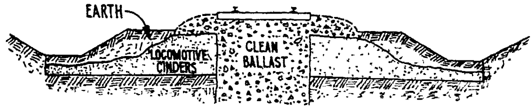
Construct side ditches at the outer edge of the right-of-way, then remove all the bad material that shows signs of squeezing out to a depth of approximately 3 feet below the bottom of the tie. Replace with locomotive ash. Restore track to its original alignment, giving a good lift and new ballast section. This scheme was tried out because a drainage system was not practicable.



TYPICAL SECTION

PLAN "E"

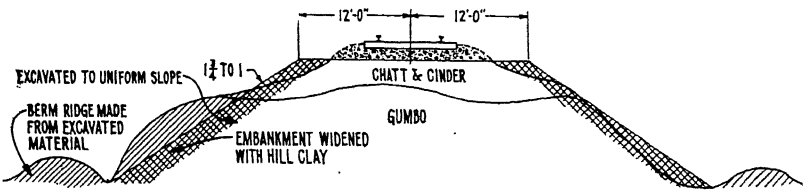
Trim slopes by cutting out bulges and working material down to a flatter slope, using some of the material to form a sort of a berm ridge near the toe of the embankment. Good filling material was then used to widen the crown of the embankment and dress the slopes.



TYPICAL SECTION

PLAN "F"

The original construction of the line was made by using some gumbo excavated from cuts. The embankment gave little trouble until the advent of heavier power. The track went down across this stretch of embankment and was pulled up and surfaced on cinders. The fills continued to settle, the gumbo squeezing out on either side of the fill. The gumbo was excavated along either side near the bottom of the fill and wasted to one side. The trench was backfilled with rock to restore the toe of the embankment and the fill was also widened. This method cured the soft track and no trouble nor excessive surfacing has occurred since the work was completed.

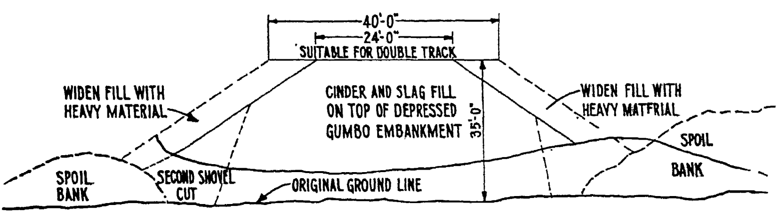


TYPICAL SECTION

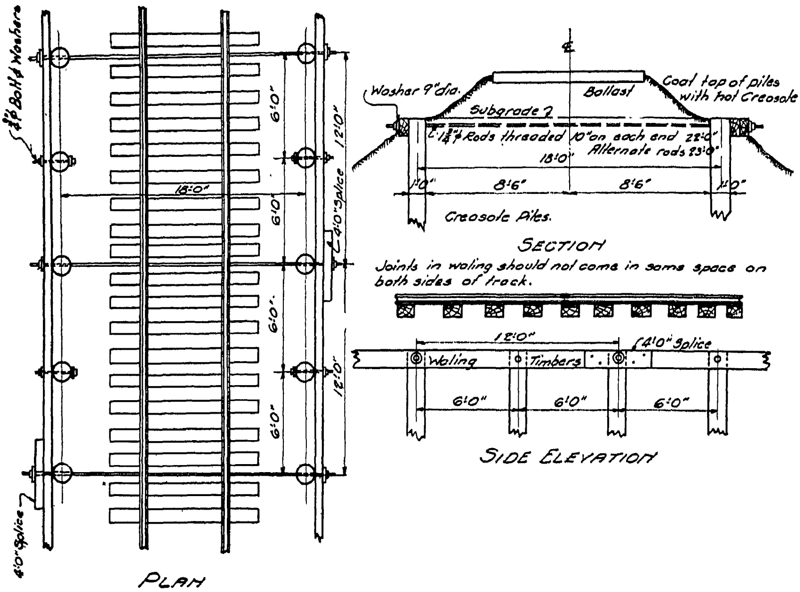
Revetment

Driving creosote piling or old scrap rails in sinking fills has proved effective where it was impracticable to get drainage—the piling or rails being driven on either side of the track and placed only a few feet apart; then tied together at the top with rods, as per sketch shown below.

Instead of using timber waling pieces, some prefer to use old rails.



TYPICAL SECTION



B.

(1) Flattening Slopes

The placing of additional material with a flat slope has prevented further sliding of embankment. In some instances it has been necessary to use a slope of 3 to 1 or more before a state of equilibrium was established.

C.

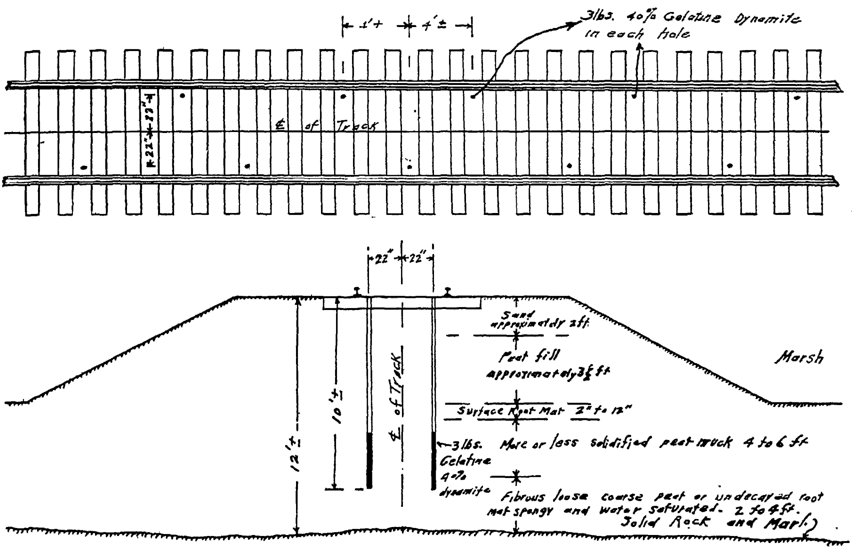
A fill was built partially of material hauled in from the hills during the winter in large frozen chunks. The pressure from traffic caused almost immediate sliding of embankment. For a number of years various remedies were applied to correct the slides, many of which aggravated the trouble rather than corrected it. The final cure was brought about by removing the bad material. This was accomplished by lining the track over to one side and then cutting out as much of the bad material as could be safely removed, replacing with good material; then lining the track to the opposite side and repeating process. To correct one of the most difficult conditions it was necessary to drive falsework, remove the bad material and re-fill with good hill dirt, making slopes 3 to 1, or sufficient to establish a state of equilibrium.

D.

(1) Dynamiting

A stretch of track had been constructed across a peat bog and marsh with peat side borrow material and sand. The material under the fill consists of surface root mat followed by more or less solidified peat muck, then a loose, coarse, fibrous peat supported on marl and limestone. The track settled from three to six inches under train load, regaining some of the subsidence after the load had passed, due to elasticity of the peat. A dynamite method was used to improve the condition. This was done by

shooting two lines of explosives—each line about twenty-two inches from center of track, with the charges of each row spaced eight feet apart and staggered. The firing was done in series with an electric machine. The lower strata of soft quagmire material immediately under the roadbed permitted the more compact and stable dry fill to settle into the voids thus created. The track settlement varied from thirteen to twenty-six inches and was raised to original grade with sand.



E.

(1) Retaining Walls

Where it was not practical to obtain additional right-of-way to permit the flattening of slopes in large cuts, retaining walls have been used to prevent further sliding of materials. Foundations of such walls should be carried below the moving materials into a stable strata.

Temporary relief has been known to correct sliding conditions in very troublesome cuts by constructing pile bulkheads about 18 feet from the center of the track.

(2) Benching

In several cases the sliding in cuts has been satisfactorily stopped by benching and removing only the upper portion of the slope.

Prevention

(a) During the construction period effort should be made to classify and place all filling material. Care should be taken to see that the fill does not contain any gumbo or other unstable material. If for reasons of economy it is necessary to use material that shows signs of being unstable, the slopes should be so flattened that equilibrium will be maintained under all conditions.

(b) In locating new lines and changing present alignment, one should investigate the character of materials in cuttings through country where unstable materials may be encountered and the soil should be thoroughly investigated and the bearing capacity

of ground where high fills will be constructed should be determined and these factors should receive due consideration before final adoption of the new line.

Conclusions

The Committee has made its report as general as it could, but believed it necessary to give some specific remedies which have been used by various railroads for special cases. Officials of railroads that report having tried these remedies advise us that they have proved very effective and they have had no further interruption to traffic or excessive maintenance expense since the work has been completed. The cause should be sought and then the cause must be removed or some new work done to prevent the settling or sliding banks in both fills and cuts.

Appendix I

(9) DESIRABLE WIDTH OF ROADBED IN CUTS AND ON FILLS AND DESIRABLE SLOPES OF BANKS UNDER VARYING CONDITIONS OF PRESENT DAY LOADINGS

W. M. Ray, Chairman, Sub-Committee; H. B. Barry, L. C. Frohman, J. N. Grim, H. T. Livingston, W. A. Murray, J. A. Noble, Roscoe Owen, E. M. Smith, H. N. White.

This Sub-Committee has examined the Manual and the recent Proceedings of the Association on this subject. A questionnaire has been submitted to the railroads represented on the Sub-Committee, and it is felt that the question of width of roadbed cannot be definitely determined until discrepancies in the standard ballast sections shown on pages 103, 104 and 105 of the Manual are eliminated.

(I) Width of Roadbed

It is, therefore, suggested that the Board of Direction be requested to assign to the Ballast Committee a reconsideration of the standard ballast sections especially with reference to sub-ballast, which might be considered as a top dressing of the roadbed section.

(II) Slopes of Banks

This Sub-Committee has found no railroad which takes train loads or speeds into consideration in establishing slopes for cuts or fills or any theory which could be applied to this question. Special cases of unstable sub-soil have received different treatments. The Missouri Pacific submits typical cross-section for stabilizing roadbed on soft ground showing a 24 ft. roadbed with side slopes of 5.6 on 1, which would be an extreme case. Generally, the matter of slopes is satisfactorily treated in the Manual.

An editorial in a recent railroad magazine calls attention to "roadbeds that have developed unstable conditions after years of service during which they had been presumed to have become thoroughly solidified. In a number of instances, indications of a growing instability of roadbeds have been reported to have followed the introduction of heavier locomotives or an increase in traffic, but it is hard to understand how this could represent other than a contributing influence." These would seem to be cases calling for improved maintenance or drainage rather than for a change of dimensions or contour of the roadbed.

This matter was covered by a sub-committee assignment reading: "The Effect of Heavier Power and Increased Tonnage upon Roadbed Previously Stable," in Vol. 25, 1924, page 362, the following remedies being suggested:

(1) Strengthen the roadbed by better drainage,
(2) Strengthen the roadbed by widening same,
(3) Help the roadbed to function properly by better distribution of the load-deeper ballast, heavier rail, etc.

The above statement has been quoted in later volumes of the Proceedings and seems to be a simple and comprehensive formula.

The above is submitted as information with the recommendation that the subject of standard ballast sections be reassigned to the Ballast Committee.

Appendix J

(10) INVESTIGATE METHODS OF PROTECTING AGAINST DRIFTING SNOW AND METHODS OF REMOVAL OF SNOW ON THE LINE AND IN YARDS AND TERMINALS

F. W. Hillman, Chairman, Sub-Committee; J. A. Given, G. F. Hamilton, Daniel Hillman, R. M. Jolley, W. A. Murray, E. H. Piper, E. M. Smith, F. E. Wiesner.

The Committee on Maintenance of Way Work Equipment has had assigned to it the subject "Types of Snow Melting Devices", which precludes their consideration in this report as to details and merits. However, it is assumed that this Committee may suggest conditions where they are applicable.

The subject assigned has two major divisions: Protection and removal. It will be divided into these two general headings.

PROTECTION AGAINST SNOW

Removal of Obstructions

Brush, trees, buildings and other obstacles which cause snow to drift onto tracks should be removed where practical and expense warrants. Consideration should be given to widening cuts so as to form space away from track into which snow will collect, and to flattening slopes of cuts which will in many instances permit the snow to pass over the track or cause only a small cover. Sometimes shallow cuts may be eliminated by raising track.

Obstruction to be Placed

Fixed Types.—Trees and shrubs properly selected as to adaptability to climate and properly planted afford an effective protection in some localities against drifting snow. The New York Central reports success on their eastern district with Norway spruce, some planted when two or three feet high and others when only seedlings.

The Western Lines of the Canadian Pacific Railway spent considerable money experimenting with the growing of trees in the prairie sections for permanent fences, but with no success. However, the Eastern Lines of the same railway have had success and their instructions for tree planting for snow fences follow:

Kind of Trees to be Used and Method of Planting

Scotch pine and spruce 12 to 16 inches high will generally be supplied for this work. Trees should be planted in two rows 4 ft. apart and staggered, the Scotch pine

is to be planted in the back row and the spruce in the front row. Planting should commence in the Spring as soon as frost is entirely out of the ground and can be continued for about four weeks. In the Fall planting may start about the first of September and can be continued until heavy frost comes.

A strip of ground at a distance from the track to be decided by the local officers 10 to 12 ft. wide should be thoroughly ploughed and harrowed for the total length of snowbreak as early in the season as possible preceding the planting of the trees. This will allow for fire protection as well as for planting. Trees of the same size should be planted together. Young trees are delivered to the line packed in damp earth in cars or in boxes and great care should be taken to see that the roots are not exposed to the atmosphere until the trees are actually going into the ground and even then to the least possible extent. Wet sacking should be used to cover trees when moving same.

If the fine roots are allowed to dry up the trees will in the majority of cases die.

To replace individual trees which, notwithstanding the utmost care, die after planting, an extra quantity of trees will be delivered over and above present requirements. These additional trees should be very carefully planted two feet apart in any suitable cultivated location. Later, when needed, trees can be carefully transplanted along with earth surrounding roots.

Cultivation

The first year after planting, the 12 ft. width above-mentioned should be kept cultivated to a depth of about three inches, using where possible a horse cultivator and handling the balance, that is, close to and around the trees, with a hand hoe. Care should be taken to see that grass, herbage, roots or rubbish are not allowed to collect around the base of the young trees, as this tends to kill the lower branches.

Preservation

In the maintenance of trees planted for snow-breaks, replacements will from time to time be necessary due to improper planting, poor soil conditions, lack of cultivation, etc. Dead trees should be removed as soon as this condition is apparent, so that they will not interfere with the growth of their neighbors, and should be replaced with new trees. In certain locations trees are liable to be attacked by disease, moths, etc. They should be carefully watched for attack in this connection, and as soon as there is the slightest indication of such attack the matter should be reported to the General Tie Agent. He will immediately arrange for inspection and application of the necessary remedy.

Pruning

The height to which the trees will be permitted to grow shall be determined by the local officers and will depend on prevailing conditions with regard to depth of cut to be protected, number of tracks involved, width of right-of-way, etc., but in no case should the trees be permitted to have an ultimate height of more than ten feet. Pruning should be done between June 1st and June 15th with a sharp knife and the cut should be made at an angle to, and not square across, the tree. To permit of the proper close growth of the trees, up to the height required, it is necessary that growth be retarded before trees reach that height, and pruning should therefore start when the trees reach a height of two feet below the final height desired. For example, if a fence with a final height of eight feet is required, pruning should start when the growth has reached a height of six feet. When this point has been reached, the growth of that year on the main stem only, which is easily apparent on account of its lighter color, should be pruned off. This will have the effect of increasing the growth of the top branches, which will spread out and grow up to form new tops to the trees. When these branches have reached the final height required for the hedge they should be kept pruned off annually, as noted above for the main stem. Pruning has the effect of accelerating the growth of the lower branches. The practice outlined if properly followed will force the development of the trees into a hedge resulting eventually in a compact and solid snowbreak.

The Chicago, Burlington & Quincy Railroad started in 1928 a project to determine whether snow-fence protection can be secured adequately and economically through the use of trees. A definite program was undertaken for the proper preparation of the

soil, the planting of the trees and their subsequent care. Plantings were made in Nebraska, Colorado and Wyoming. The results have been gratifying. A detailed account is contained in Railway Engineering and Maintenance of July, 1931.

Built Fence

Snow fences of the fixed types are set on the right-of-way frequently acting as right-of-way fence. The most generally used type is the wood fence with horizontal board as shown in A.R.E.A. Manual. Of late, however, much use is being made of wooden or steel slat and wire fencing placed on steel or wood posts. Old ties placed on end or as a worm fence are effective, but in a short time rot out and become unsightly. Old box-car doors placed on right-of-way fence posts make an effective snow fence and are cheap where storms are not too severe, but where necessary to resist high winds are quite costly on account of additional supports required. Wooden fences require considerable maintenance and are easily damaged by fire and in many places are lost by theft. A suggested type consists of 11-ft. treated posts with eight-inch corrugated steel sheets, 18 gage, 14 ft. long. Posts are spaced to make two panels for each 14-ft. board allowing for overlap. In extreme cases and where snow slides are frequent snow sheds may have to be used.

Portable Types.—The type shown in the A.R.E.A. Manual is frequently used although in many instances is being replaced with the slat and wire type placed on steel posts, which were necessary to resist heavy winds, is guyed with wire to bolts or wood stakes driven into the ground. This slat and wire fence can be quickly erected and moved. Also if long steel posts are used the fence can be raised if desired when snow has piled up. There are metal portable fences, but so far as known have not been in use long enough to determine if their life justifies first cost. Sometimes snow can be thrown up by hand into banks or ridges back of fixed or portable fences in emergency with good results.

Locating Obstructions

No definite rule can be stated for locating snow fences with respect to points they are to protect. The topography for some distance away from track has such a bearing on action of storms that it cannot be said that all similar points can be adequately protected with the same type of fence set the same distance out. Then, too, storms differ so much in their intensity and action from year to year that it is uneconomical to build a fixed fence that will afford protection against the severest storms. It is more economical to construct a fixed, or first-line defense fence where experience dictates to care for the average storm and place portable fences of a type which can be quickly erected for a second or third line defense as occasion requires.

The following is submitted as a general rule for use of snow fences:

The location at which fixed snow fences are to be built, the length of such fences and their distance from center of track shall be determined from a study of action and effects of storms. Fixed snow fences should be constructed on the right-of-way or incorporated as a part of the right-of-way fence. Types of fence to be such as will protect against average storm. Roadmasters' districts to be provided with sufficient portable fence which can be easily and quickly transported and erected, to be placed back of fixed fences for a second or third line defense or at locations where fixed fences cannot be properly erected, as severity and frequency of storms demand, a requirement which may vary in amount and location from year to year.

SNOW REMOVAL

On Line

Removal on the line suggests first the flanger for snow ten inches deep or less, then the wedge or push plow placed on pilot of locomotive for occasional light drifts of up to two feet above rail, then the larger wedge or push plow placed on loaded ballast or gondola cars. Great care must be exercised in use of these to provide some means of preventing cutting edge being forced down on top of rail by weight of snow and catching in frogs, switches and crossing planks. This can be prevented by a narrow casting placed under plow near cutting edge so as to ride on rail and keep plow up. This may inject complications if used in yards where self-guarded frogs are used. There is a plow on the market which is extensively used which appears to have overcome this difficulty. Ditchers with front incased plow shape for eight or ten feet above rail make excellent snow movers. Where the snow is not too deep the spreader wings can be used to good advantage to move the snow farther from the track after the first opening through the drift has been made. The rotary must be used for the deeper drifts. However, attempts to use them in shallow drifts not deep enough for reasonably full contact of wheel may cause wheel to race too much under light load and damage machine. Some railroads, particularly in Canada, have a complete line of specially designed plows to meet varying conditions. No general rule seems applicable for use of these machines, as much depends on whether snow is wet or dry.

When operating flangers, rotary plows, etc., over the line the problem of keeping ice and snow out of guard rails, frogs and switches is important, particularly where located so as to be difficult for sectionmen to get to them in severe storms. One railway reports overcoming this difficulty by carrying cans of carbide on plows and at such places put carbide on the ice to be removed, within a minute or two the carbide gets sufficient moisture to form gas which is ignited, heat generated and ice melted.

In Yards or Terminals

The method for removal of snow in yards and terminals and at stations depends upon physical layout, density of traffic and amount of snow. If snow is not very deep possibly it is best not to remove it from tracks, except to make flangeway by hand shovelling, or with flangers if traffic will permit, and cleaning out of switches by hand or snow melters. The use of the latter requires good drainage to carry away melted snow or it may freeze and cause more trouble than the snow, or heat must be great enough to evaporate water. Frequently switch engines are equipped with a perforated pipe laid across track under pilot and steam blown through it to clean away snow. If traffic is not too dense this may be successful, but in dense traffic districts another engine added is often a nuisance. Then, too, if not judicially used it may be simply a case of blowing snow back over places already clean. Casing Head gasoline and Hydrocarbon sprinkled over snow and ignited is also used.

In clearing yard tracks it is well to first pull cars off of four tracks, run a plow down one track and following with spreader push snow clear of adjacent tracks, then run down them with spreader and repeat operation until snow is piled too high for further spreading. Then start on other side of pile and repeat. In some instances where snow is not too heavy and yard not wide snow has, by this method, been pushed clear across yard and picking up avoided. However, this cannot always be done and piles of snow must be left to melt or loaded onto cars either by hand or crane with excavating bucket. In extremely heavy snow rotary plow may have to be used to open up tracks.

In cleaning snow off station platforms where snow fall is light, hand method is probably the cheapest. Throwing snow onto tracks should be prohibited as passing trains may throw snow over waiting passengers on platforms, particularly so in suburban district stations where trains do not stop and run through at high speed. Use should be made of baggage trucks on which to load and carry away snow. Small wooden hand push plows are effective. Where snow is heavy large horse-drawn scrapers are effective.

At team yards the use of plows on front of auto trucks or tractors is very effective. Snow can be pushed to center or side of drive and left to melt, or loaded into trucks or cars by hand or excavating machinery.

General

It is very desirable to keep ahead of storms and not let lines become blocked if reasonably possible. To get best results in keeping the line open during snow storms it is essential that snow plows be started from terminals before the storm actually breaks and in severe storms additional plows despatched at such intervals as will preclude the formation of snow banks that cannot be moved with plows. Prompt clearance of cuts before further snow or wind storms is quite necessary as it is succeeding storms which generally cause real trouble. Consideration should be given during severe storms to holding trains in terminals and stations and possibly the abandonment of trains and yard switching until storm abates and line is opened. Meteorological reports should be made available for division officers and/or general officers should keep local officers informed of the progress of approaching storms.

All of this must be done with orderliness and forethought. In the Fall a general program should be formulated for stationing snow fighting equipment at vantage points, outlining a general supervisory plan, and methods by which men can be secured, fed and relieved.

This report is presented as information with recommendation that the subject be reassigned for an opportunity to enlarge on the information and revise information contained in the Manual.

Appendix K

(12) SPECIFICATIONS FOR PIPE LINE CROSSINGS UNDER RAILWAY TRACKS

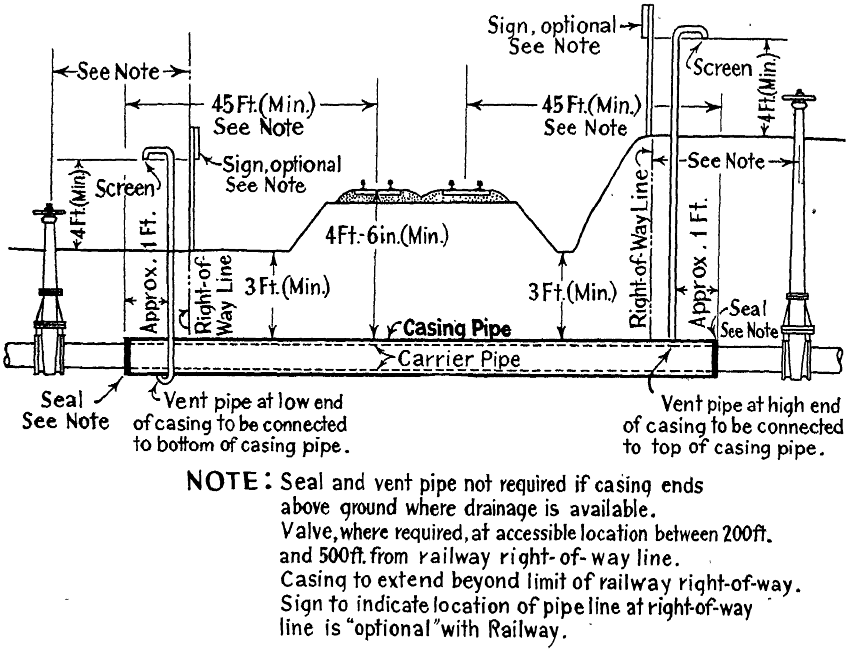
P. T. Simons, Chairman, Sub-Committee; J. B. Akers, C. W. Baldridge, G. H. Burnette, J. A. Given, H. H. Harman, W. J. Lank, E. H. Piper, J. B. Trenholm, H. N. White.

Pipe lines included under these specifications are those installed to carry oil, gas, gasoline or other inflammable or highly volatile substance, under pressure, or any substance which from its nature or pressure might cause damage if escaping on or in vicinity of railway property. Gas transmission and distribution lines in city streets, carrying less than 45-lb. pressure, are not to be considered as coming under these specifications.

1. Pipe lines under railway track and right-of-way shall be encased in a larger pipe or conduit installed as indicated in figure below:

The casing pipe or conduit is the essential feature of the plan. Some of the other features as described in following paragraphs are optional in certain cases.

2. Carrier line pipe inside of casing under railway track and right-of-way shall be of good construction (usually the same as either side of railway) of steel, wrought iron, cast iron, pure or alloyed iron; and shall be either seamless or substantially welded pipe; with welded, coupling, or other "approved" joints. Pipe shall be laid with slack (no tension) in the line or with expansion joint near point of railway crossing.



3. Casing pipe and joints may be of any approved conduit construction and shall be capable of withstanding load of railway roadbed, track and traffic; also shall be so constructed as to prevent leakage of any matter from the casing or conduit throughout its length under track and railway right-of-way except at ends of casing or conduit where ends are left open, or through vent pipes when ends are sealed to outside of carrier pipe.

Casing shall be installed with even bearing throughout its length and shall slope to one end.

Inside diameter of casing shall be at least 2 inches greater than largest diameter of carrier pipe, joints or couplings.

4. Where ends of casing are below ground they shall be suitably sealed to outside of carrier pipe and properly vented above ground with vent pipes not less than 2 inches in diameter and extending not less than 4 feet above ground surface. Vent pipe at low end of casing shall be connected with bottom of casing and vent at high end shall be connected with top of casing. Top of vent pipe shall be fitted with down turned elbow properly screened.

Where ends of casing are at or above ground surface and above high water level they may be left open, provided drainage is afforded in such manner that leakage will be conducted away from railway tracks or structures. Where proper drainage is not provided, end of casing shall be sealed.

5. Where practicable the depth from base of railway rail to top of casing at its closest point shall be not less than 4½ feet and on other portions of railway right-of-way where casing is not directly beneath any track the depth from surface of right-of-way and from bottom of ditches to top of casing shall be not less than 3 feet. Where it is not practicable to secure the above depths, special construction shall be used.

6. Casing shall extend across railway right-of-way and at least 45 feet each side from (measured at right angles to) center line of any track nearest end of casing.

7. Where local conditions warrant, suitable shut-off valves and/or telephone shall be provided in pipe company's lines at conveniently accessible locations between 200 feet and 500 feet outside of railway right-of-way lines.

8. Pipe lines shall, where practicable, be located to cross tracks at approximately right angles thereto and shall not be closer than 45 feet to any portion of any railway bridge, building or other important structure which might be injured by leakage from or failure of the pipe line.

Pipe lines, casing pipe and vent pipes shall be at least 4 feet (vertically) from aerial electric wires and shall be suitably insulated from underground conduits carrying electric wires on railway right-of-way.

9. Crossings under railway tracks of pipe lines carrying extremely volatile or highly inflammable material such as gasoline shall, where practicable, be located near the summit of the topography where the ground surface slopes downward away from the railway in at least two directions.

10. Plans for a proposed crossing shall be submitted to and meet the approval of the Chief Engineer of the railway before installation is begun and the execution of the work on railway right-of-way, including the supporting of the track, shall be subject to his inspection and direction.

Recommendation

It is recommended that this report be adopted for inclusion in the Manual.

REPORT OF COMMITTEE XIV—YARDS AND TERMINALS

H. L. RIPLEY, *Chairman;*
J. R. W. AMBROSE,
IRVING ANDERSON,
C. E. ARMSTRONG,
J. E. ARMSTRONG,
C. J. ASTRUE,
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H. F. BURCH,
W. F. CUMMINGS,
A. W. EPRIGHT,
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E. D. GORDON,
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G. F. HAND,
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W. J. HEDLEY,
H. O. HEM,
W. H. HOBBS,
NOAH JOHNSON,
E. T. JOHNSTON,
E. K. LAWRENCE,
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J. L. LOIDA,
L. L. LYFORD,
C. P. MCCAUSLAND,
E. H. MCREYNOLDS,
M. J. J. HARRISON, *Vice-Chairman;*
C. H. MOTTIER,
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T. R. RATCLIFF,
H. M. ROESER,
W. B. RUDD,
W. C. SADLER,
C. U. SMITH,
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E. E. R. TRATMAN,
H. L. VANDAMENT,
E. P. VROOME,
H. M. WAITE,
A. P. WENZELL,
J. L. WILKES,
Committee.

To the American Railway Engineering Association:

Your Committee on Yards and Terminals respectfully presents reports covering the following subjects:

(1) Revision of Manual (Appendix A). It is recommended that revisions or additions relating to (a) hump yards with retarders and (b) test weight cars be approved for publication in the Manual.

(2) Produce Terminals (Appendix B). It is recommended that the 40 items listed in the report be approved for publication in the Manual, and the condensed summary of replies to questionnaire be received as information.

(6) Hump Yards (Appendix C). It is recommended that the report be received as information.

(8) Location and design of air-ports in co-ordination with railway facilities (Appendix D). It is recommended that the report be received as information.

(9) Scales used in railway service: Rules for Maintenance and Transportation of Track Scale Test Weight Cars, and Definition of a Standard Test of a Railway Track Scale (Appendix E). It is recommended that the report be received as information.

(10) Bibliography on subjects pertaining to yards and terminals (Appendix F). It is recommended that the data be received as information.

Progress is reported on subjects (3) Effect of motor coach and truck service on design of way and terminal station facilities; (4) Provisions for parking and garage facilities for private automobiles of railway passengers at passenger terminals and way stations; (5) Grain elevator storage yards and plant tracks; (7) Co-ordination of facilities at rail and water terminals.

Respectfully submitted,

THE COMMITTEE ON YARDS AND TERMINALS,

H. L. RIPLEY, *Chairman.*

Bulletin 350, October, 1932.

Appendix A

(1) REVISION OF MANUAL

H. L. Ripley, Chairman, Sub-Committee; M. J. J. Harrison, Vice-Chairman; J. E. Armstrong, H. M. Bassett, E. J. Beugler, E. H. Fritch, W. H. Giles, G. F. Hand, E. M. Hastings, E. T. Johnston, C. U. Smith and E. E. R. Tratman.

HUMP YARD WITH RETARDERS

Many factors local to each situation affect efficient operation of a retarder yard so that each terminal must be studied independently to produce a proper design.

The following formulae may be used in designing retarder hump yard gradients running from the crest of the hump to the lower end of the classification yard. The results are expressed in terms of the required vertical drop.

A = Total drop in feet from the crest of the hump to the clearance point of any track in the classification yard (Distance $D + D_1$) = not less than $D\ Z + D_1\ Z_1 + \Delta\ C$.

B = Drop in feet from leaving end of last retarder in any group to clearance point of any track in the group (Distance D_1) = $D_1\ Y + \Delta_1\ C_1 + a + b$.

A minus B = Drop in feet from crest of hump to leaving end of last retarder.

In which

C = Curve resistance of hard rolling cars under adverse conditions expressed in feet drop per degree of central angle.

C_1 = Curve resistance of easy rolling cars under favorable conditions expressed in feet drop per degree of central angle.

D = Distance along the track from crest of hump to leaving end of last retarder.

D_1 = Distance along the track from leaving end of last retarder to clearance point of any track in the group.

Δ = Total curvature in degrees of central angle in distance $D + D_1$.

Δ_1 = Total curvature in degrees of central angle in distance D_1.

Z = Per cent gradient equivalent to the average resistance of hard rolling cars under adverse conditions in distance D.

Z_1 = Per cent gradient equivalent to the average resistance of hard rolling cars under adverse conditions in distance D_1.

Y = Per cent gradient equivalent to the average resistance beyond the last retarder, under favorable conditions, (summer weather, assisting wind, etc.) of the heavy easy rolling cars normally handled.

a = Switch resistance in distance D_1.

b = Allowance in feet drop for accelerative increment over and above all other resistances in distance D_1.

If the layout requires four points of retardation in each route, or if the distance from the crest of the hump to the last retarder is unusually long, it may be necessary to divide the distance D into two parts each with its own rate of maximum resistance, modifying Formula A accordingly.

Distance D_1 extends from the leaving end of the last retarder in any group to the straight portion of the classification tracks, or as much farther as is necessary to reach the most distant clearance point in that group. This clearance point in the yard is that which it is intended all cars shall reach before stalling under adverse conditions.

If it is desired to deliver the hard rolling cars (empties) under adverse conditions to a point still farther down in the classification yard, it will be necessary to add to Formula A the amount $D_2\ Z_2$ representing respectively the additional distance from the clearance point to such farther point and the gradient equivalent to the average resistance of hard rolling cars under adverse conditions over distance D_2 (Z_2 could be expected to be smaller in amount than Z_1).

An illustration of the quantities to be substituted for the different symbols, and a typical example of their application, are shown on pp. 130 to 133, Vol. 33, Proceedings.

TEST WEIGHT CARS

Paragraphs 2 and 3 of Section VI—Test Weight Cars, of "Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales" (pages 1032 and 1033, 1929 Manual), read as follows:

2. Test weight cars should have the following characteristics:
   - (a) All-metal construction.
   - (b) Length of wheel-base not to exceed 7 feet.
   - (c) Load distributed uniformly on wheels.
   - (d) No unnecessary ledges or projections likely to catch or hold dirt.
   - (e) No unnecessary parts.
   - (f) Strength and durability, so that frequent repairs will not be necessary.
   - (g) Surface area reduced as much as possible, to limit wind pressure.
   - (h) Accessibility of all parts for inspection.
   - (i) Roller or ball bearings of proper design, preferably the former.

3. Test weight cars should preferably be of the self-contained type with solid body in which a small space is provided for a limited number of test weights. When it is impracticable to provide a self-contained car, a compartment car, with body of structural and plate steel, at least one-half of the weight of which consists of test weights carried in the compartments, may be found to be serviceable.

It is proposed to delete this material from the Manual, renumber the Section as "VII", renumber paragraphs 4 to 11, inclusive, as, respectively, paragraphs 2 to 9, inclusive, and insert as new Section VI the following material. This material was submitted as information as a part of this Committee's report to the 1932 Convention, and appears here without change.

SPECIFICATIONS FOR RAILWAY TRACK SCALE TEST WEIGHT CARS

1. Definition

A railway track scale test weight car is a car used for determining the weighing performance of railway track scales, and as an accessory in determining their mechanical condition. Such cars are essentially standard test weights and must be given the consideration becoming to formal standards of mass.

2. Classification

According to the body design, test weight cars are classified into two types. The first named is the preferred type.

(a) Self-Contained Type.—The self-contained type of test weight car has a body made up of either one or two castings, with space provided to contain a small number of fifty-pound standard test weights.

(b) Compartment Type.—The compartment type of test weight car has a body either of castings or built up of steel shapes and heavy plates with space for standard test weights of fifty or one hundred pounds each to a value at least equal to the weight of the empty car.

3. Primary Requirements

(a) WEIGHT.—The nominal weight of any test weight car shall be some integral multiple of 10,000 pounds.

(1) Minimum Weight.—A car used for track scale testing purposes must not weigh less than 30,000 pounds.

(2) Maximum Weight.—The weight of a track scale test weight car should be as great as conditions of roadbed, bridge restrictions, and other essentials of safe transportation and use permit. (Cars weighing 80,000 pounds comprise a majority in use. The tendency is toward heavier cars. Some are in use that weigh 100,000 pounds. Certain useful and recommended testing practices require a light car and a heavy car in combination. For these purposes it is preferable that the weight of the heavy car be a simple multiple of the weight of the light car.)

(b) DESIGN CHARACTERISTICS.—The following features of design are required of satisfactory track scale test weight cars:

(1) All-metal construction.
(2) Two-axle construction, with wheelbase not to exceed seven feet.
(3) Load uniformly distributed on wheels.
(4) No air-operated brakes (see Section 6, paragraph e, herein).
(5) Roller, or other form of anti-friction journal bearings.
(6) No unnecessary equipment.
(7) A minimum of ledges, cavities or projections that will hold dirt, water, or other foreign matter.
(8) Minimum surface area.
(9) Smooth and sloped top to insure drainage.
(10) Accessibility of all parts for inspection.
(11) Ruggedness and durability in order to minimize repairs.

4. Body Features

(a) CASTINGS.—Body castings shall be of gray cast iron or semi-steel and must be smooth, uniform, and free from blowholes, blisters and shrinkage cracks. Fins and burrs must be removed. Castings must be cleaned by sand blasting or other equally effective methods. Adequate allowance must be made for finish on parts that require machining.

(b) DISTRIBUTION OF BODY WEIGHT.—The design and construction shall be such that the body weight is symmetrically distributed about either side of vertical planes through the longitudinal and transverse center lines. The center of gravity shall be as low as practicable and in any event low enough to insure safe transportation at usual operating speeds.

(c) BODY SHAPE.—The sides and ends of test car bodies shall be vertical. The top shall be symmetrical about the longitudinal center line and, exclusive of runways, shall have a slope of approximately 1 to 5.5. Necessary pockets and recesses shall, in so far as possible, be made self-cleaning. The design must provide reasonably easy accessibility of every part of the body for hand cleaning by brush or air nozzle.

(d) SIZE.—The size of the body shall be such that the overall dimensions of the car will come within the clearance diagram of the owner road within the margins required by formal regulations for safety, and not exceed existing A. R. A. Clearances.

(e) TOOL, SUPERCARGO AND WEIGHT COMPARTMENTS.—Each test car shall be provided with a tool and supercargo compartment which shall run transversely through the body of the car.

(1) Method of Closing.—All compartments shall be closed with doors dust and water tight. Doors shall be freely hinged and shall not be too heavy for one man to lift or swing.

(2) Locks.—Compartment doors shall be provided with means for locking with padlock, combination lock or other equally effective device.

(3) Drainage.—Means for drainage of accumulated moisture quickly and completely from all compartments shall be provided.

5. Running Gear

(a) Wheels and Axles.—Wheels and axles shall be of forged steel and shall conform to A. R. A. rules for strength, quality and workmanship. Wheels shall be 36 inches in diameter.

(b) Journal Bearings.—Test cars shall be equipped with roller or ball bearings of an approved type designed for oil lubrication. Boxes shall be constructed to prevent loss of oil at all running speeds. The design shall permit easy examination of bearings and renewal of lubricant. Means for draining oil from each box shall be provided. Bearings must be constructed to take lateral thrust. In all respects the type of bearing must meet A. R. A. standards for performance and safety.

(c) Pedestals.—The bearing boxes shall fit between pedestal jaw castings rigidly attached to the car body. Renewable steel wearing plates shall be provided.

(d) Springs.—Semi-elliptical springs of adequate design, and suitable means to protect same against corrosion, shall be provided.

(e) Stability of Movement.—The design of the running gear in combination with the body must provide against the possibility of derailment due to spring failure, or due to galloping, side or diagonal sway on any track passable for running or switching purposes at the usual speeds of freight movement. Spring stops are recommended. Bottoms of journal boxes in nominal position shall have not less than 1½ in. clearance over pedestal tie bars or caps.

6. Brake Gear

(a) Hand Brakes.—Test cars shall be equipped with an efficient hand brake conforming to A. R. A. standards.

(b) Air Line.—Test cars shall be equipped with an 1¼ in. through, self-draining air line, standard angle cocks and hose connections.

(c) Brake Beams.—Brake beams shall be A. R. A. standard.

(d) Brake Shoes.—Brake shoes shall conform to A. R. A. standard and shall be painted red, or some other distinctive color which shall be specified by the owner road.

(e) Air Brakes.—Air brakes are considered detrimental to the maintenance of accuracy of weight. When operating rules of the owner road require, they may be installed.

7. Draft Gear

Draft gear shall be of the friction type, conforming to A. R. A. standards and specifications.

8. Couplers

(a) Type.—Couplers shall be A. R. A. standard—bottom operated.

(b) Striking Plates.—Removable striking plates shall be securely fastened to the car body back of the coupler horn, designed to take coupling shocks in the event of failure of the draft gear.

(c) PAINTING.—Couplers, lifting mechanism and knuckles shall be painted red or some other distinctive color which shall be specified by the owner road.

9. Safety Devices

Safety appliances must conform to I.C.C. requirements.

10. Fittings

(a) STANDARD.—Fittings such as flag brackets, lamp sockets, etc., shall be installed as required by formal regulations.

(b) REPAIR WARNING.—A metal plate shall be securely fastened to each side of the car, or where it is conspicuously visible from both sides of the car, bearing the following legend in 1-in. letters—"Do not oil boxes or make repairs to this car unless directed by scale inspector."

(c) CARDING PLATE.—A small plate or fixture shall be attached to each side of the car to permit the fastening or holding of routing tags or cards.

11. Painting

(a) FILLER.—After sand blasting, the surface shall be further prepared for painting by application of a suitable metal primer and filler such as commonly used for machine tools, locomotives and tanks.

(b) PAINT AND FINISH, except as otherwise specified herein, shall be as specified by the owner.

12. Stenciling

(a) WEIGHT LEGEND.—The designed weight shall be conspicuously stenciled on each side of the car.

(b) WARNING LEGEND.—The following warning shall be stenciled on each side of the car in letters at least 3 in. high—"Haul on rear end of Train".

(c) STANDARD.—Other stenciling shall be as required by the owner.

13. Supercargo Identification

Car movers, tool boxes, clothing containers and all items of supercargo furnished with the car are not part of the car weight and shall be conspicuously marked by painting, badge or otherwise to furnish easy and positive identification as parts not included in the nominal weight of the car.

14. Compartment Cars

(a) TYPES PROHIBITED.—

(1) Split Body.—Compartment cars consisting essentially of two compartments longitudinally divided by a runway on the car center line at floor level are unsatisfactory.

(2) Scrap Metal, Billet or Other Lading.—Compartment cars loaded with billets, scrap metal, concrete, or any other material except standard test weights of known value, are unsatisfactory.

(b) LADING TO BE FIXED.—Means shall be provided to prevent shifting of the lading of compartment cars. This may be accomplished by means of pockets, grooves, wedging, or otherwise. The possibility of damage to lading or car due to shocks of handling must be positively and permanently eliminated.

Appendix B

(2) PRODUCE TERMINALS

E. T. Johnston, Chairman, Sub-Committee; H. L. Ripley, M. J. J. Harrison, R. A. Black, W. O. Boessneck, W. F. Cummings, L. L. Lyford, C. P. McCausland, W. C. Sadler, C. U. Smith, H. M. Waite, A. P. Wenzell.

The report presented at last year's convention, appearing in Vol. 33, pages 116 to 125 inclusive, has been reviewed and the following material is submitted with the recommendation that it be adopted for inclusion in the Manual.

A condensed summary of data obtained from a questionnaire circulated in 1931 is submitted as information.

PRODUCE TERMINALS

General Type

(1) Produce terminals are designed for expeditious and economical delivery of fruits, melons, vegetables, and sometimes butter, eggs and live poultry.

(2) Terminals should be located and designed to handle peak business.

(3) A union terminal serving the entire trade of a community is preferable.

(4) The location must be convenient for dealers with easy access over wide and well improved highways and easy gradients. It should have convenient railroad connections. A location adjoining a railroad terminal yard is advantageous.

(5) A produce terminal usually includes a team yard and buildings for display, sale and storage of produce. Any or all of the following facilities may be required:

a. Receiving yard
b. Inspection and hold yard
c. Team yard
d. Buildings divided into separate stores
e. Buildings for display and private sale
f. Buildings for display and auction
g. Auction rooms
h. Office, restaurant, etc.
i. Cold storage warehouse
j. Icing facilities
k. Bulk delivery platforms
l. Inspection platforms
m. Live poultry platforms
n. Ripening facilities
o. Reconditioning facilities
p. Auto truck scales
q. Incinerator
r. Farmers' market
s. A track system serving the yards and buildings
t. A system of driveways for truck movements
u. Communication service
v. Fire protection facilities

Buildings

(6) Ample floor space should be provided for mechanical handling from cars to warehouse floor, display of produce and assembly of various lots for delivery to trucks.

(7) Column spacing should be given careful study and be as wide as possible, consistent with economic design.

(8) Back-up space for trucks should be as liberal as possible.

(9) Canopies should be provided to protect produce while unloading from cars and delivering to trucks.

(10) Ample provision must be made for natural and artificial lighting.

(11) The roof, walls and floor should be properly insulated to help control temperatures.

(12) Special attention should be given to the floor material on account of the continued trucking and the commodities handled.

(13) Proper drainage must be provided to insure sanitary conditions.

(14) Special features should be considered, such as heating, refrigeration, air-conditioning, ripening rooms and special requirements of the dealers.

(15) Space must be provided for cooperage.

(16) Offices and auction rooms are usually located at one end of the building or in a second story. Auction rooms require exceptionally good lighting, ventilation and acoustic treatment. Auction rooms should have sloping floor arranged in steps for seating accommodations.

(17) Restaurant space is usually required in the larger terminals.

(18) Where the terminal consists of a number of individual stores, the requirements should be worked out in advance with the dealers. Elevators, platform scales, and other special facilities may be required. Consideration should be given to the proper metering of all services provided.

(19) The economical width of auction and private sales buildings appears to be between 70 feet and 110 feet.

(20) Shelters, properly heated and lighted, should be provided for team yard checkers.

Track Layout

(21) The track layout should be as compact and flexible as possible and extensive enough to take care of traffic without delay. It is governed by the number of cars handled at peak periods, the different kinds of produce received, and the average standing time until cars are released.

(22) A receiving yard is sometimes desirable for receiving transfers from various roads and for assembling empties and reconsigned cars.

(23) A hold and inspection yard is sometimes provided. This yard should have inspection platforms and cars should be accessible for icing. It may be a separate yard or combined with the receiving yard.

(24) Team yards should have ample standing capacity. Extremely long tracks should be avoided.

(25) Track centers should be not less than 13 feet.

Driveways

(26) Team yard driveways should be hard-surfaced and have at least 45 feet clear width between cars.

(27) Driveways between buildings or between a building and a team track should have preferably a clear width of 80 feet.

Platforms

(28) Inspection platforms should be 4 feet 6 inches to 6 feet wide, 3 feet 3 inches above top of rail and at least 5 feet 9 inches from center line of tangent track. Platforms should be covered and lighted.

(29) Platforms used exclusively for handling live poultry should be 16 feet to 20 feet wide, 3 feet 5 inches above top of rail and at least 5 feet 9 inches from center line of tangent track. Platforms should be covered and light and water provided. Roof supports should be located to minimize interference with handling crates. Space for crate storage and repairs is usually required. Facilities for handling live poultry business should be accessible for trucks, but located as far as possible from produce houses.

(30) House platforms, when served by both highway vehicles and railway cars, should be 4 feet above top of rail and 8 feet from center line of tangent track.

(31) Clearance must comply with State regulations.

Icing

(32) All cars in team and hold yards should be accessible for icing which is usually done by contract with local dealers. Access may be from narrow driveways or from icing platforms.

Garbage and Refuse Disposal

(33) Cars should be thoroughly cleaned after unloading and all refuse and garbage removed from platforms, buildings, etc. Special equipment such as sweepers, dump carts, etc., should be provided in large terminals. Garbage may be handled by city collection, by contract, or incinerated. An incinerator, if required, should be of ample capacity to handle one day's collection in six to eight hours, conveniently located, and designed to burn garbage having a high water content.

Miscellaneous

(34) Ample drainage is essential for buildings and yards.

(35) Flood lighting the entire area is desirable in addition to local lighting.

(36) The entire area should be strongly and closely fenced to prevent trespass.

(37) Definitely assigned entrances and exits should be provided.

(38) A cold storage warehouse, if required, should have suitable track service and convenient means of communication with other buildings.

(39) Adequate parking space should be provided.

(40) Auto truck scales, when required, should be located at a point convenient for the drivers and near the freight office. The location should not interfere with truck movements in the driveways.

CONDENSED SUMMARY OF DATA OBTAINED FROM 1931 QUESTIONNAIRE: PRODUCE TERMINALS

TERMINAL NUMBER	1	2	3	4	5	6	7	8	9	10	11	Min.	Max.	Ave.	Suggested
a. Width of house	90′	70′	90′	100′	70′	90′	110′	100′	60′	90′-110′	70′-100′	60′	110′	88′	70′-110′
b. Width of platform															
1—track side	8′	6′	8′		7′	8′	6′	8′	10′	8′-10′	8′	6′	10′	8′	8′
2—driveway side		6′	4′		7′		6′	8′	20′	10′-16′	10′-20′	4′	20′	11′	X
c. Width of team driveways	44′	60′	80′	41′	50′-65′	50′	65′	45′	50′	52′	46′	41′	80′	54′	45′-65′
d. Width of driveways															
1—between houses			40′		55′		96′			60′-110′	68′-110′	40′	110′	77′	80′
2—between house and team track	74′	60′	38′		97′	97′	50′	70′		75′		38′	97′	70′	80′
e. Clearances															
1—center line of track to platform	8′	8′	6′	5′-8″&8′	8′	8′	8′	7′-4″	8′	8′	6′	5′-8″	8′	7′-5″	8′
2—top of rail to floor	3′-9″	4′	3′-6″	3′-6½″		3′-9″	4′	3′-6″ to 4′-1″	3′-9″		3′-6″	3′-4″	4′-1″	3′-9″	4′
3—top of driveway to floor	3′-9″	4′	3′-6″	3′-6½″		3′-9″	4′	3′-6″	3′			3′	4′	3′-7½″	4′
f. Inspection platforms															
1—width		4′-6″	5′	13′&20′	4′-6″&8′	4′-6″	4′-6″	5′-6″			6′	4′-6″	20′	*5′-3″	4′ 6″ to 6′
2—top of rail to floor		3′-5″	3′-6″	3′-6½″	3′-2″	3′-3″	3′-5″	3′			3′-3″	3′	3′-6½″	3′-4″	3′-3′

*This average is exclusive of No. 4, as these platforms are also used for re-conditioning.

Appendix C

(6) HUMP YARDS

E. M. Hastings, Chairman, Sub-Committee; N. C. L. Brown, H. F. Burch, W. F. Cummings, R. J. Hammond, G. F. Hand, M. J. J. Harrison, E. T. Johnston, T. R. Ratcliff, H. L. Ripley, W. B. Rudd, E. P. Vroome.

Last year the Committee's report was on the subject of gradients for the hump and classification yard where retarders are used. The report set up formulae (Vol. 33, page 129) for determining the required drop in feet from the crest of the hump to the clearance point of any track (formula A), the drop in feet from the leaving end of the last retarder in any group to the clearance point of any track in that group (formula B), and the drop in feet from the crest of the hump to the leaving end of the last retarder (formula A–B). Several methods of applying these formulae were set down and an example worked out for a typical yard with 45 classification tracks, using the data at hand in respect to the various resistances.

This year the Committee has studied what has been termed graphic methods which may be used in designing gradients in connection with the application of retarders to hump yard operation. After a classification yard has been laid out and the required vertical drops have been determined the distribution of these drops in their respective zones may be worked out by graphic methods in order that the speed of cars may be properly controlled and each retarder do its share of the work. The graphic method may be also used in making an analysis of the grades and retarder capacities of an existing yard as well as in the study of any design under consideration. As information for the Association the Committee is presenting two graphic methods:

Graphic Method "A" is an application to a typical classification yard of 45 tracks as shown on Fig. 1 of last year's report and is explained and its application demonstrated under the sub-heading Graphic Method "A".

Graphic Method "B" is an application to a typical classification yard of 50 tracks as shown on the accompanying Fig. 5 and is explained and its application demonstrated under the sub-heading Graphic Method "B".

GRAPHIC METHOD "A"

General

The factors of car speed, car rolling resistance, curve resistance, gradient and retarder capacity may be expressed in terms of velocity head based on the law of freely falling bodies; viz.,

$$v^2 = 2\,gh$$

$$\text{or } h = \frac{v^2}{2\,g}$$

where h = the height through which a body must fall to acquire a velocity of v ft. per sec.

Converting this basic formula to fit our requirements we have:

$$VH = 0.0334\,V^2$$

where VH = feet vertical height through which a car drops, or "velocity head"
V = speed of a car in miles per hour

The following table is worked out from this formula:

Velocity Heads in Feet for Free Rolling Cars

M.P.H.	*.0*	*.1*	*.2*	*.3*	*.4*	*.5*	*.6*	*.7*	*.8*	*.9*
2	0.13	0.14	0.16	0.17	0.19	0.21	0.22	0.24	0.26	0.28
3	0.30	0.33	0.35	0.37	0.39	0.41	0.43	0.46	0.48	0.50
4	0.53	0.56	0.59	0.62	0.65	0.68	0.70	0.74	0.77	0.80
5	0.84	0.87	0.90	0.93	0.97	1.01	1.05	1.08	1.12	1.16
6	1.20	1.24	1.28	1.32	1.37	1.41	1.45	1.50	1.54	1.60
7	1.64	1.68	1.73	1.78	1.83	1.88	1.93	1.98	2.03	2.09
8	2.14	2.19	2.25	2.30	2.35	2.41	2.47	2.53	2.59	2.65
9	2.71	2.77	2.83	2.89	2.95	3.01	3.08	3.14	3.21	3.27
10	3.34	3.41	3.48	3.54	3.61	3.68	3.75	3.82	3.89	3.96
11	4.04	4.12	4.18	4.26	4.34	4.42	4.50	4.57	4.65	4.73
12	4.81	4.89	4.97	5.06	5.14	5.22	5.30	5.38	5.47	5.55
13	5.64	5.72	5.82	5.91	6.00	6.08	6.16	6.26	6.36	6.45
14	6.55	6.64	6.73	6.82	6.92	7.02	7.12	7.22	7.31	7.41
15	7.52	7.62	7.72	7.82	7.92	8.03	8.12	8.23	8.33	8.44
16	8.56	8.67	8.77	8.89	9.00	9.11	9.21	9.32	9.43	9.55
17	9.66	9.78	9.90	10.00	10.12	10.23	10.34	10.46	10.58	10.70

The velocity head (*VH*) corresponding to the speed of a car at any point may be read from the above table. For example, a car running at a speed of 5.0 M.P.H. has a velocity head of 0.84 ft.

Car Resistance

Car rolling resistance is commonly expressed in the equivalent rate of grade. Thus, a resistance of 6 lb. per ton is equivalent to an adverse grade of 0.30 per cent, which, in a distance of 100 ft., becomes a negative velocity head of 0.3 ft. The prevailing direction and velocity of the wind will influence the quantities used for car resistances.

Curve resistance, as noted in the previous report (Vol. 33, page 129) is expressed in feet drop (velocity head) per degree of central angle. Switch resistance is also expressed in equivalent feet drop. Both of these will be negative.

Gradient

The rate of grade in per cent, times the distance in 100 ft. stations, gives the gradient velocity head at any point. This will be either positive or negative, depending on whether the gradient is descending or ascending.

Retardation

The retarding capacity of a car retarder is commonly expressed in terms of the velocity head the retarder can subtract from a freely moving car of given weight. This velocity head capacity of retarders of different lengths and for different weights of cars may be obtained from the manufacturers.

Graphic Method

The graphic method may best be described by illustrating its application to a specific layout. As the layout shown on Fig. 1, "Retarder operated classification yard, typical head end layout", Vol. 33, page 132, has already been used to illustrate another method, this same layout has been selected to illustrate the graphic method.

Attached is Fig. 2 entitled "Graphic Method for Use in the Design of Hump Yard Gradients and for Distance-Speed Studies, Tracks 43 and 44"; which illustrates the method applied to the tracks for which the calculations were made in Fig. 1. The graph is based on the heavy easy rolling car under favorable conditions as retarder capacities and the grade below the last retarder are involved, but the action of any car may be

studied in a like manner by substituting suitable resistances. The following resistances are those used for Fig. 1 (Vol. 33, page 132) and also used in this report:

Car rolling resistance between the hump crest and the last retarder, including switch resistance = 6 lb. per ton (0.3 per cent grade)
Car rolling resistance below the last retarder, not including switch resistance = 4.4 lb. per ton (0.22 per cent grade)
Average switch resistance below last retarder in any group = a = 0.15 ft. drop or velocity head
Accelerative increment below last retarder = b = 0.10 ft. drop or velocity head
Curve resistance = 0.025 ft. drop or velocity head per degree of central angle
Capacity of each retarder = 2.2 ft. velocity head for a 100-ton car

The procedure for laying out the diagram in Fig. 2 follows:

(a) Draw the horizontal base line $A\ K$ and show on it to scale, the location and number of the retarders leading to track 43 and the location and central angle of the curves (Track 44 is the same on the other side of the yard). The distances shown on this base line must be taken along the track and *not* on the center line of the yard. The number and capacity of the retarders will have been determined by the calculations at the bottom of page 132, Vol. 33, that is, six (6) retarders, each with a capacity of 2.2 ft. velocity head. Draw vertical lines representing the center line of a car as it enters and leaves the three retarding positions; these lines have been assumed at 18 ft. ahead of and following each retarder position for the average car.

(b) Lay off the points B, C, D, etc., at such distances below the base line AK that, at each of these designated points, the distance from the line AK will represent the cumulative velocity head of car rolling resistance, curve resistance and switch resistance. The completed line $ABCDEFGHI$ will then represent, at any point, the velocity head of all such resistances.

(c) Lay off vertical distances AL, NO and KM, representing the velocity head equivalent to the humping speed at the apex (assumed at three (3) M.P.H.).

(d) Lay off vertical distance MJ equal to "A", the total drop from the crest of the hump to the clearance point (formula I, page 132, Vol. 33. This is increased to 17.44 ft. in order to utilize the full capacity of the retarders with a margin of safety of 0.5 ft. as explained on that page.)

(e) Lay off vertical distance OP equal to "A–B" (formula III, page 132, Vol. 33, increased by 0.02 ft. as in (d)). OP equals 15.35 ft. Locate point H where this vertical line intersects the car resistances line. Vertical distance HP will then represent the velocity head of the assumed car running unretarded from the apex of the hump at L to the leaving point of the last retarder, the total car resistances NH having been deducted. Lay off vertical distance PQ, representing the retarding capacity of the 6 retarders (13.20 ft. velocity head) which is 0.5 ft. greater than the velocity head of the unretarded car at point P. This shows that the car can be stopped by full application of all 6 retarders in that route, with a margin of safety of 0.5 ft. velocity head.

(f) Lay off vertical distance $Q\ R$, representing the velocity head capacity of the last pair of retarders (4.4 ft.). It is now desired to obtain vertical distance $G\ S$ representing the velocity head equivalent to the speed of the car entering the last retarding position. This may be done either by assuming this entering speed or by assuming the gradient through the last retarders. However (see Vol. 33, page 130), this gradient should be between the limits of 0.80 per cent and 1.20 per cent. For this illustration and on the basis of average traffic, assume a minimum gradient through the last retarders of 1.00 per cent. Referring to Fig. 1, it will be noted that the track leads to the three groups which include track 43 must of necessity come together at a common elevation just ahead of the last retarders (S on the graph). Also, A–B (formula III, page 132,

Vol. 33) will determine the drops to the points immediately following the last retarders in these three groups. Then, with 1.00 per cent as a minimum gradient through the last retarders, the gradient through the last retarders leading to tracks 43 or 44 becomes 1.16 per cent. Lay off line *RS* at this rate of grade. This establishes point *S*, and *GS* becomes 2.92 ft. velocity head (equivalent to a speed of 9.35 M.P.H.). Line *Q S* will then represent the retarding effect of the two retarders. Draw line *PS′* parallel to *RS*. *PS′* becomes part of the profile.

(g) Four points on the profile have thus far been established—*L*, *S′*, *P* and *J*. The material adopted last year for inclusion in the Manual contains the following (Vol. 33, page 115):

"This drop—between the crest of the hump and the last retarder—should be so apportioned that:

(a) The hump gradients will quickly separate the cars or cuts to provide the spacing necessary for the free throwing of switches.
(b) The gradients through the last retarder are sufficient to start an average rolling car which has been stopped in the last retarder."

The latter of these two requirements has already been complied with in establishing point *S′*. Adoption of proper hump gradients is necessary to fulfill the first requirement. The desired drop between the crest of the hump and the leaving end of the first retarding position is dependent on the humping speed (already assumed as 3.0 M.P.H.) and the desired speed of the car leaving the first retarding position. Experience indicates that a speed of 6 M.P.H. at this point is within the limits of good practice for the assumed car when fully retarded.

Assuming then this speed of 6.0 M.P.H., lay off vertical distance *C X*, the equivalent velocity head, and vertical distance *X Z* representing the velocity head of retardation of the two retarders (4.4 ft.). This establishes point *Z* on the profile. Thus the two points *L* and *Z* on the profile are established. It is axiomatic that the crest of the hump profile shall be a vertical curve, and this part of the profile could be completed by connecting point *Z* with the vertical curve. However, this would not provide a sufficiently quick break-away for cars, and point *Y* on the profile may be determined by assuming an entering speed at the retarders or by assuming a first gradient over the crest which will provide the desired quick break-away. In this illustration the latter method has been followed, and a 4 per cent gradient used for a sufficient distance and in combination with a 2.5 per cent grade through the retarders. This fixes point *Y* on the profile; join *Y* and *Z*. The profile now becomes line *L Y Z*. This same profile has been found to work out with entire satisfaction in a yard handling mixed traffic. It should be borne in mind, however, that there is nothing obligatory about the humping speed of 3.0 M.P.H., the leaving speed of 6.0 M.P.H. or the assumed 4.0 per cent gradient. Various combinations can undoubtedly be worked out that will give entire satisfaction for the cars to be handled. The figures assumed are merely to illustrate the method and at the same time to be within the limits of what has been found to be good practice. Join *Y* and *X*; line *Y X* then represents the retarding effect of the two retarders.

(h) Six points on the profile have now been determined, *L*, *Y*, *Z*, *S′*, *P* and *J*. The profile could be completed by connecting points *Z* and *S′* if only the leads to tracks 43 and 44 had to be considered. However, examination of Fig. 1 (Vol. 33, page 132) shows that the leads to all tracks must be on the same gradient from the crest to a point just beyond the first lap switch. It is therefore necessary to work out at least a portion of the profile for track 0 before the profile for tracks 43 and 44 can be completed. This is done in the same manner as previously described for track 43 and is shown on Fig. 3.

From Fig. 3 we find that the gradient of track 0 from Z to S' is 1.895 per cent if these two points are connected by a straight line. A different method of designing this grade is described further along, but for present purposes the 1.895 per cent grade is used.

(i) Returning now to track 43 (Fig. 2), lay off line $Z\,W'$ on a gradient of 1.895 per cent and join points W' and S'. It is found that the rate of grade between W' and S' is 1.66 per cent (W' is located a reasonable distance beyond the last frog of the first lap switch). Draw $X\,W$ parallel to $Z\,W'$ and $W\,V\,U$ parallel to W' and S'. Vertical distance $E\,V$ then represents the velocity head equivalent to the car speed on entering the second retarding position. Lay off vertical distance $U\,T$ representing the retardation velocity head of the retarders at this location (4.4 ft.). Vertical distance $F\,T$ then represents the velocity head equivalent to the car speed on leaving the second retarding position and $V\,T$ represents the retarding effect of the two retarders. Connect points S and T.

(j) The completed profile for tracks 43 and 44 is line $L\ Y\ Z\ W'\ V'\ U'\ S'\ P\ J$ and, graphically, the vertical distance between the profile and the resistance line $A\ B\ C\ D\ E\ F\ G\ H\ I$ represents the velocity head of the car if unretarded. Similarly, line $L\ Y\ X\ W\ V\ T\ S\ Q$ represents the velocity head of the car when fully retarded in each retarding position.

(k) In practical operation a car will not be stopped in the last retarder but will be slowed down to such speed that after leaving the last retarder it will couple at a safe speed. Dashed line $H\,I$ represents the equivalent gradient of car resistance between the leaving end of the last retarder and the clearance line in the yard, as in (b). Lay off vertical distance $I\,I'$ velocity head equivalent to the safe speed of a car at the clearance line; if the classification tracks are on a non-accelerating grade for the heavy easy rolling car under favorable conditions (0.22 per cent), the car speed at the clearance line should be at a safe coupling speed, say 4.5 M.P.H., equivalent to a velocity head of 0.68 ft. Referring to Vol. 33, page 131, in the next to the last paragraph, we find the principles in respect to the gradients between the last retarders and the clearance line in the yard. The velocity head of the assumed car when leaving the last retarder ($H\,H'$) will depend on whether it is desired that the car accelerate or not accelerate between these two points. If no acceleration is desired, $H\,H'$ will be the same as $I\,I'$, viz. 0.68 ft., equivalent to a speed of 4.5 M.P.H. In Fig. 1 "$a + b$" is made 0.25 ft. (Vol. 33, page 132), which may be divided as follows:

a = Average switch resistance between the last retarder and the clearance line = 0.15 ft. drop
b = Allowance in feet drop, for accelerative increment over the same distance = 0.10 ft. drop

Accordingly, the velocity head $H\,H'$ will be 0.68 ft. minus 0.10 ft. equals 0.58 ft. which is equivalent to a releasing speed of 4.2 M.P.H. The average gradient will then be line $P\,J$ parallel to line $H'\,I'$. This gradient $P\,J$ may be broken up to meet the requirement of bringing the five tracks together, in the same way as was done in establishing point W', and to provide an accelerating grade immediately following the last retarder. If "b" is made a minus quantity in order to decelerate cars, as in grading method 7 (Vol. 33, page 131), "b" would be added to the velocity head at the clearance line, thus making the releasing speed at the last retarder higher than the speed at the clearance line.

(l) The Speed-Distance Chart may be drawn as shown at the top of Fig. 2, translating the velocity heads of the fully retarded car at different points into speeds.

(m) The chart for track 0, shown in Fig. 3, may be drawn and completed in the same manner; the total drop "a" has been increased as in last year's report, to take advantage of the full capacity of the retarders.

Modifications of the details of the method as illustrated may be used if desired. For example, there is no reason why a profile should not be worked out for the heavy easy rolling car under favorable conditions by assuming entering and leaving speeds at each retarder location, and then checking the profile thus obtained by the formulae in last year's report in order to ensure that the drops from the hump crest to different points are sufficient for proper operation of the yard. In the actual design of a yard it is necessary to bring the different routes and grades together at the switches and also to provide gradients on the routes to the outside tracks which will give car speeds as nearly as possible equal to the car speeds on the routes to the middle tracks. This necessitates a cut and try method.

Fig. 3 shows for track 0 in dashed lines how the car speeds may be varied within certain limits to obtain more nearly constant car speeds in the retarder zone or to change the time interval from the hump apex to any point to prevent interferences.

(a) The solid line in the speed distance chart shows that the heavy easy rolling car on the gradients as worked out for Fig. 1 will have a speed of 6.0 M.P.H. leaving the first retarding position, the car having been fully retarded. Likewise when leaving the second retarding position the car speed will be 5.0 M.P.H. The gradient of 1.0 per cent through the last retarding position fixes the car speed entering this position at 9.6 M.P.H.

(b) If it is desired to more nearly equalize the speeds of the car between Z and S' on the profile, a speed of 9.6 M.P.H. may be assumed on entering the second retarding position, equivalent to a velocity head of 3.08 ft. at $D\,M'$. A speed of 6.0 M.P.H. may be assumed on leaving the second retarding position, equivalent to a velocity head of 1.20 ft. at $F\,N'$. $N'\,O'$ will represent the retardation velocity head of the two retarders equal to $T\,U$ (4.4 ft.).

(c) On connecting these points as shown, the grade of the track necessary to effect these changes in speed would be 1.643 per cent between the first and second retarding positions, 2.53 per cent through the second retarding position, and 1.635 per cent between there and the last retarding position. A possible objection to this is that the 1.643 per cent grade would apply through the turnouts at the first lap switch where curve resistance is encountered and the steeper grade of 1.895 per cent in accordance with the plan may be considered more advantageous. It is to be noted that the actual differences in speeds and time intervals are very small.

(d) It is good practice to install sufficient retarder capacity to permit stopping the heavy easy rolling car under favorable conditions in the last retarder to prevent possible collisions, where cars are not in the clear on the classification tracks. Ordinarily, retarder capacity is not provided to permit stopping cars in any other of the retarding positions. If it should be considered desirable in some specific design or method of operation to be able to stop cars in the first retarding position, then additional retarder capacity at least equal to $C\,X$ should be installed in this position without changing the profile, as stopping a car would be unusual and not a regular operation. Obviously, it would be poor practice to reduce the speed of the fully retarded car leaving the second retarding position to a figure materially less than 5.0 M.P.H. as this would then tend to become a point limiting the humping capacity of the entire yard.

This same graphic method as illustrated by the foregoing may be applied to a yard layout requiring four retarding positions and any number of retarders, or to a speed-distance chart in analyzing the gradients of an existing yard. It is of particular value in plotting a speed-distance chart or a time-distance chart to determine if there is any interference between the cars of low and high rolling resistances that may be next to each other in the train being humped. This study is necessary in determining the ar-

rangement and spacing of switches to the different tracks depending on the class and weight of cars it is expected to handle in the yard, and will determine the necessary speed or intervals between cars being pushed over the hump.

This graphic method may also be applied to advantage in analyzing the effect of the seven different methods of complying with the formulae for drops from the apex to the last retarder and to the clearance line, these seven different methods being shown on pages 130 and 131 of Vol. 33, and applying principally to the method of grading between the last retarder and the clearance line and to the resulting cross-section of the classification yard tracks.

GRAPHIC METHOD "B"

The gradients of several of the retarder hump yards, now in operation, were designed with the assistance of a graphic method which was developed in connection with the application of retarders to hump yard operation and which will be described in this report.

This method has been utilized to advantage in designing the gradients, with relation to the location of retarders in the track layout and to provide a proper spacing of cars in their travel from crest to clearance, these objectives being essential for obtaining a maximum efficiency. It provides for the coordination of the effects of rolling resistance, retardation and gradients upon the speed of a car as it moves down the hump, and provides a medium through which the time and distance spacing between cars may be determined. If the spacing is determined at various points in the switching area, locations may be found where the capacity for humping cars is limited. Then, suitable corrections can be made.

(I) Basic Principles

All factors, speed, rolling resistance, and retardation may be expressed in terms which are common to each other, as for example vertical height, gradients and equivalent gradients. Velocity head is used, commonly, in railway engineering to represent the effect of gravity upon the speed of moving trains or cars. However, a broader application of the term has been made in the development of this method. Conversion formulae have been developed as follows:

(a) Speed

In 1927 this Committee developed a velocity head formula which may be found on page 655 of Vol. 28 of the Annual Proceedings. However, a slightly different method of developing the formula, as well as a slightly different value, is presented in this report.

$VH =$ Velocity head of a car at any point of travel

$$KE = \text{Kinetic energy} = \tfrac{1}{2}\, M\, v^2 = \frac{W}{64.4}\, v^2 \qquad (1)$$

$W =$ Weight of car or cars

$g =$ Acceleration of gravity — 32.2 ft/sec/sec

$M = \text{Mass} = \frac{W}{g} = \frac{W}{32.2}$

$v =$ Velocity in ft/sec $= 1.467\ V$

$V =$ Speed in M.P.H.

$h =$ Vertical height through which car or cars have moved

$$PE = \text{Potential energy} = Wh \qquad (2)$$

Gravity is potential energy which is converted into kinetic energy when a car is allowed to roll on a negative gradient. Therefore, if car resistance is neglected:

$PE = KE = Wh = \frac{W}{64.4} v^2$ ....From (1) and (2)

$h = \frac{1}{64.4} v^2 = .0155\ v^2$ ....(3)

VH or velocity head is used to represent height h so, therefore, formula (3) becomes

$VH = .0155\ v^2$ (v given in feet per sec) .... (4)

Substituting — $v = 1.467\ V$

$VH = .0334\ V^2$ (V given in miles per hour) ....(5)

The formula, developed in 1927, provides for an allowance of 5 per cent for the effect of the rotative energy stored in the wheels of a moving car, which is desirable when dealing with the tractive effort required for hauling trains but which is not considered necessary when dealing with the running of cars by gravity. Therefore, the 5 per cent allowance has not been used in testing car resistance or in applying the results.

(b) Rolling Resistance

Rolling resistance values should be represented either by equivalent gradients, or by vertical heights or drops as set forth in this Committee's report found on page 129, Vol. 33. However, to facilitate description and to coordinate all factors the term VH_f is used to represent the velocity head of car resistance.

VH_f or F = Equivalent Gradient (in per cent) $\times$ distance (in 100 ft. stations)..(6)

(c) Retardation

Retardation values may be expressed in several different terms, such as, pounds per axle, equivalent drawbar pull, per cent retardation, or velocity head, the last named being preferable for this method of designing gradients. Velocity head values for the retarders utilized at present, will vary directly with the length of the retarder and with the weight of car, but with certain limitations as to the minimum weight of car to be retarded.

Therefore, when and as required, each manufacturer should be requested to furnish velocity head values for their design of retarder with relation to definite lengths of retarder and to the weights of cars to be retarded.

VH_r or R = Velocity head of a retarder location and for a specific weight of car..(7)

(d) Gradients

To facilitate description and coordinate all factors the term VH_g is used to represent the vertical heights or drops relating to definite lengths of track.

VH_g or G = Gradient (in per cent) $\times$ distance (in 100 ft. stations)............(8)

(e) Coordination of Factors

The factors represented in items (a) to (d) inclusive may be coordinated as shown in Fig. 4.

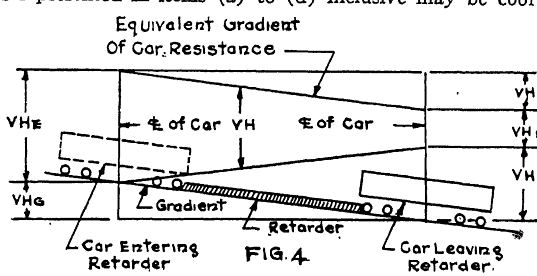


FIG. 4

VH_e = Velocity head of car entering a retarder
VH_1 = Velocity head of car leaving a retarder

The velocity head values shown in Fig. 4 can be arranged in an equation which may be used for solving for unknown factors:

$VH_e + VH_g = VH_f + VH_r + VH_1$ ....(9)

or for simplicity letters VH may be dropped leaving the suffix letters to represent the various factors as:

$E + G = F + R + L$..(10)

(II) Application to the Design of Hump Gradients

The report of this Committee, found in Vol. 31, page 781, gives information and typical track plans which will be found useful in designing the switch layout between the hump lead and the classification tracks and in arranging the space required for retarders. It will be noted that, for the group track arrangement, three and occasionally four retarder locations (see Fig. 5), in sequence, are provided, depending upon the number of tracks in the yard, the number of tracks in each group, the use of lap switch layouts, etc.

The usual arrangement provides for the installation of retarder units in numbers of: two or three on the hump lead, depending upon general requirements in height of hump or average gradient from crest to clearance; two ahead of each group of tracks; one or two on each track at the intermediate locations, two being used if a steep sublead gradient is desired. Various other combinations may be used when either the track groups or their gradients cannot all be made of a uniform design. However, the principles of design may be applied separately to each different condition.

Therefore, in designing a track layout, decisions should be made as to the number of tracks for each group, the general arrangement of subleads, the number of retarder locations, and the number of retarder units for each location. The number of units selected for the hump lead, at this stage of design, is not important since, at this location, the addition or elimination of retarder units, usually, will not affect the track arrangement as seriously as at other locations. A study of the design and operation of existing yards will be helpful in making these decisions.

Even though the above and other precautions have been taken and a well designed compact track layout has been made, the gradients should be adapted so that the car speeds are suitable for the most efficient operation. Therefore, the following application of the basic principles outlined in Section I will be found useful in the design of the gradients.

Fig. 6 shows four retarder locations in sequence, an equivalent gradient representing rolling resistance, a velocity head profile representing the speed of a car, retarded as required, and the hump profile. It will be noted that at each location there is a diagram similar to that shown in Fig. 4 and described under Section I and that between retarder locations the velocity head profile shows an acceleration of the car.

The velocity head profile may be defined as follows:

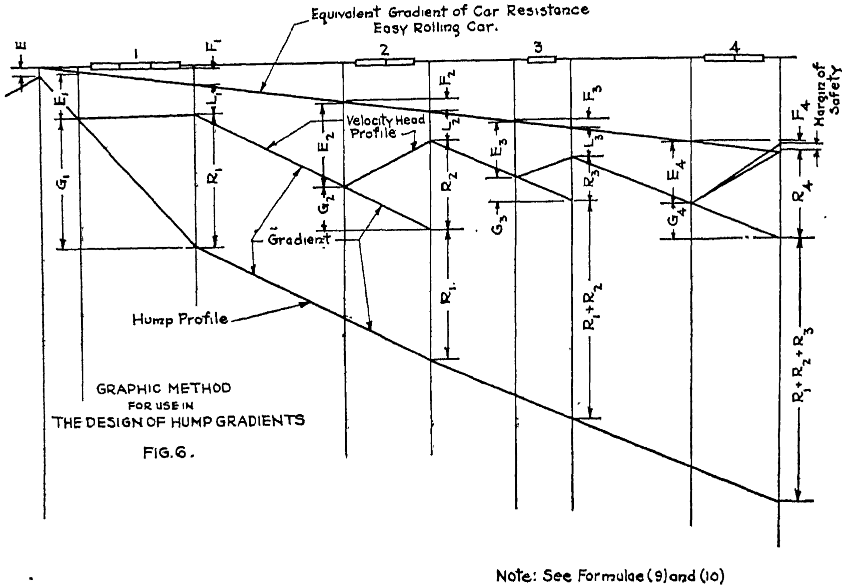
E represents the speed of a car when released at the crest; E_1 represents the speed of the car entering and L_1 represents the speed of the car leaving the first retarder location; E_2, L_2, E_3, L_3, and E_4 represent similarly the entering and leaving speeds at the second, third and fourth retarder locations. No releasing speed is shown at the fourth location since the usual practice is to design the gradients so that the car can be stopped. If a margin of safety is desired it may be included as shown but should be included in R_4.

Retardation is represented by R_1, R_2, R_3, and R_4, values having been determined in accordance with Section I, Item (c). At each location retardation values are shown as

follows: 1st location, R_1; 2nd location, R_1 and R_2; 3rd location, R_1, R_2 and R_3; 4th location, R_1, R_2, R_3 and R_4. This defines a relation between the velocity head profile and the complete hump profile.

The procedure suggested for laying out the diagram in Fig. 6 follows:

(a) Draw a horizontal line representing the track for which the gradients are to be designed and show, on this line, the retarders as they are located in the track plan (Fig. 5). Also draw vertical lines representing the centerline of a car as it enters and leaves the retarders.



(b) Draw a line to represent the equivalent gradient of rolling resistance for the easy rolling car. This may or may not be a straight line depending upon whether the track is curved or tangent or a combination of both, and upon the allowances for curve resistance. (See page 130, Vol. 33 of the Proceedings.)

(c) Lay off retardation value R_4.

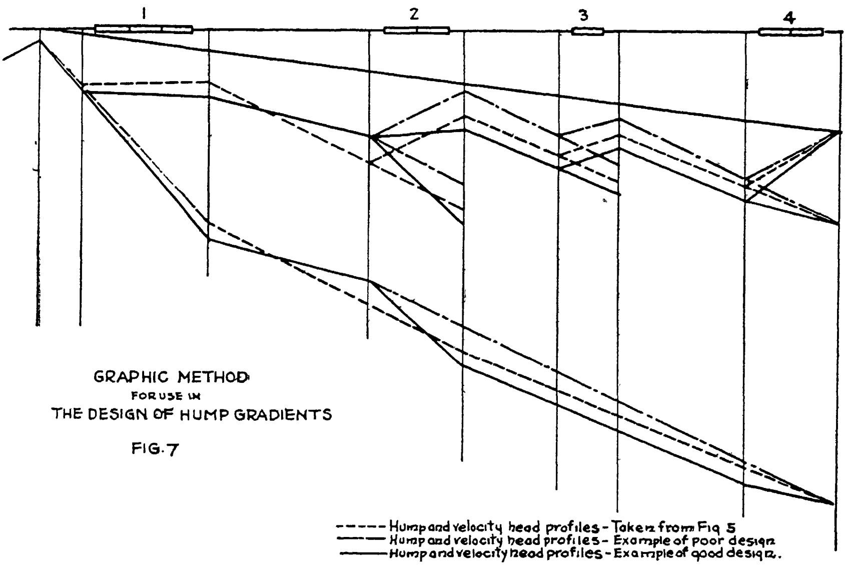
(d) Lay off L_3 to represent the speed desired for a car leaving location No. 3 and either E_4 to represent the speed desired for entering location No. 4 or draw a line connecting the points determined by laying off R_4 and L_3 thus determining E_4. The part of the line between L_3 and E_4 forms part of the velocity head profile and the entire line between L_3 and R_4 represents the gradient at that location.

(e) Similarly, as in (d), lay off L_1, R_2, L_2, and R_3 and draw the connecting lines.

(f) Lay off E to represent the speed of a car when released at the crest of the hump and R_1 to represent the retardation of location No. 1 and draw a connecting line.

(g) Complete the velocity head profile by drawing lines to connect E_1 to L_1, E_2 to L_2, etc., these lines being used to represent the speed of the car while in the retarders.

Fig. 7 consists of three hump profiles with their corresponding velocity head profiles, designed to illustrate some of the variations which may be found and to describe alterations which usually should be made in the profile as first obtained as well as to point out objectional features which should be avoided. The dotted lines represent the profiles as first obtained by the procedure described above and illustrated in Fig. 6. The full lines represent the profiles, as altered to provide a specific gradient at one location and more satisfactory car speeds throughout the descent from the crest to the last retarder. The broken lines represent a profile which, frequently, is obtained when little, if any, attention is given to the speeds at which the cars must run if they are to be delivered to their classification track without suffering damage.



GRAPHIC METHOD
FOR USE IN
THE DESIGN OF HUMP GRADIENTS

FIG. 7

Experience has shown that gradients within a definite range are desirable at some locations such as, for example, at the last retarder where they are recommended to be 0.8 per cent to 1.2 per cent. (See page 130, Vol. 33 of the Proceedings). The required alterations in the profile first obtained (Fig. 6) may be made by laying out the desired gradient in the velocity head profile and by changing either the gradient to the next location or the leaving speed at that location, the latter having been chosen only as an example. The alterations are shown in full lines at locations No. 3 and No. 4 in Figure 7.

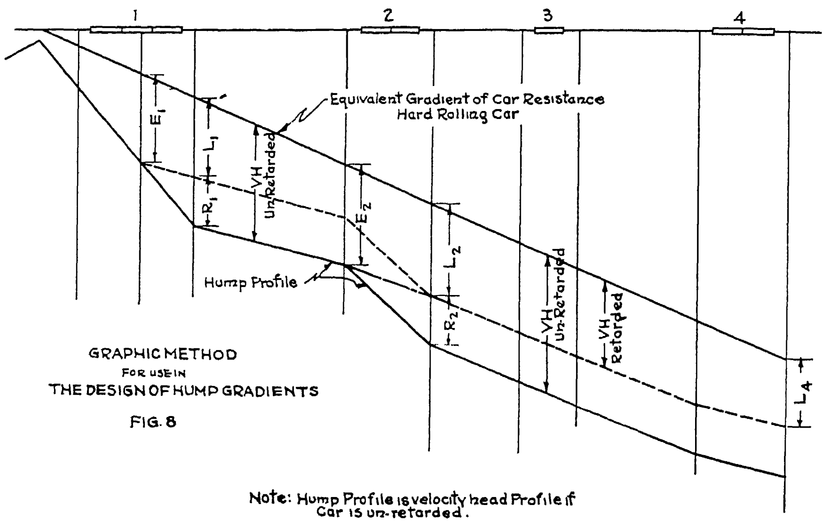
In Fig. 6 the leaving speeds L_1, L_2 and L_3 are similar in magnitude so therefore, since this is considered to be advantageous, alterations of these speeds have been shown by full lines, in Fig. 7, to make them conform to the alterations made in L_3, as described in the preceding paragraph. The entering speeds also were changed, proportionately, with exception to E_2 which was lowered, since in Fig. 6 it will be noted that E_2 is considerably higher than E_3 or E_4, and since a fairly uniform car speed is desirable.

Irregular car speeds, such as shown by broken lines in Fig. 7, are undesirable. The leaving speeds L_2 and L_3 are very low, but L_2 is lower than E, the speed at which cars are released at the crest. If such a condition is allowed to exist, within the switching area, the humping capacity of the yard may be seriously impaired, since only a few

cars, requiring a handling of this nature, will interfere with other cars, and to the extent of affecting the speed of the train being humped.

The foregoing description has dealt with the hump and the sublead to only one of the groups of tracks. The method may be applied, however, in designing the gradients for the subleads of the other groups, if care is taken to avoid altering the gradients already designed, without giving consideration to the effect which the alterations might have in the respective car speeds.

It is recommended that, in using this method, the design of the hump gradients should be based upon handling the heavy easy rolling car under favorable running conditions. However, the height of the hump should be sufficient to cause the hard rolling car to run to clearance or farther, under unfavorable running conditions. Therefore, it is advisable to apply the formulae, as found on page 129, Vol. 33 of the Proceedings, to determine if the height of hump, as designed, is satisfactory for handling the hard rolling car.



GRAPHIC METHOD
FOR USE IN
THE DESIGN OF HUMP GRADIENTS
FIG. 8

A velocity head profile representing the movement of a hard rolling car may be utilized advantageously to illustrate the adequacy of the height of hump, the car speeds to be expected, and the locations where it may be desirable to use retardation. Also it may show locations where retarders can be eliminated or should be added. Obviously any alterations in the number of retarders will require revision in the gradients.

Fig. 8 shows the hump profile as finally obtained in Fig. 7, together with an equivalent gradient representing the car resistance of a hard rolling car. If retarders are not used, the hump profile becomes the velocity head profile, but if the retarder at location No. 1 is used the velocity head profile is altered as shown by the dotted line, or if the retarder at location No. 2 is used the velocity head profile is altered as shown by the broken line and the dotted line through location No. 4.

The leaving speed L_4 should be sufficient to provide the momentum necessary to carry the car at least to the clearance point. After the classification track gradients have been designed, the velocity head profile can be completed to show approximately the location where the car will stop. If this location is not beyond the clearance point,

the height of the hump should be increased and retarder should be added, thus requiring slight alterations in the profile.

If it is found necessary to retard the hard rolling car, it is preferable to do so at location No. 1, thus following the dotted velocity head profile, which provides car speeds nearer to those of the easy rolling car. (See full line velocity head profile Fig. 7). Such an arrangement will provide a fairly uniform spacing between cars even though hard rolling and easy rolling cars are handled alternately.

Fig. 6, 7 and 8 were drawn separately to facilitate the description. In actual practice all profiles are superimposed on one sheet.

Appendix D

(8) THE LOCATION AND DESIGN OF AIRPORTS IN CO-ORDINATION WITH RAILWAY FACILITIES

G. F. Hand, Chairman, Sub-Committee; Irving Anderson, J. R. W. Ambrose, R. J. Lockwood, E. H. McReynolds, C. H. Mottier, H. L. Ripley, H. M. Roeser, W. C. Sadler, C. U. Smith, A. Pendleton Taliaferro, Jr., E. E. R. Tratman, J. L. Wilkes.

(1) Extent of Air Lines and Facilities

The extent to which air transport services have grown is shown by the attached map, Fig. 1, and the following summary taken from the Air Commerce Bulletin, of the Department of Commerce, dated August 1, 1932. Figures include mail, passenger and express service within the United States and from points in the United States to foreign points.

	Airway miles between cities served	*Plane miles scheduled daily average*
Total Domestic	29,724	127,623
Total Foreign	19,051	13,341
Grand Total	48,775	140,964

Number of Air Transport Services in Operation

Domestic Routes	103
Mail	71
Passenger	91
Express	83
Foreign Routes	15
Mail	14
Passenger	14
Express	12
All Routes	118
Mail	85
Passenger	105
Express	95

Number of Scheduled Air Transport Operators

Domestic	33
Foreign	6

There are now three transcontinental air lines. One may travel continuously by air from New York (Newark Air Port) to San Francisco (Oakland Air Port), a distance of 2,766 miles, in 31 hours and 45 minutes. That is, leaving Newark at 9:00 AM (EST)

and flying without overnight stops via Chicago, Cheyenne and Salt Lake City, one arrives in San Francisco at 1:45 PM (PST) the next day. The fastest eastbound elapsed time is about 5 hours less, or 26 H. 54 M. By another route, via Kansas City and Los Angeles, a distance of 2,979 miles, with two overnight hotel stops enroute, one may leave New York (Newark Air Port) at 9:30 AM (EST) and be in San Francisco at 11:25 AM (PST) the second day. Continuous air travel may also be had from New York to Jacksonville, Chicago to New Orleans, Chicago to El Paso, and by connecting planes to other points, in correspondingly short times.

Nearly all of the passenger transport lines carry mail, as the mail subsidy is necessary from a financial standpoint. Nearly all of the transport lines also carry express matter, and the air express business is rapidly growing, the principal commodities being special news service, bank checks forwarded for clearing, moving picture news reels, small electrical instruments, and the like, where quick transportation is of vital importance.

So-called "air freight" is at present limited to one line between Milwaukee and Detroit. Air transport does not seem a fertile field for freight, as the weight and size of shipments necessarily must be limited.

(2) Co-ordination Between Rail and Air Services

By comparing Fig. 1, Map of Air Transport Lines, with Fig. 2, Map of Principal Railroad Lines in the United States, the necessity for co-ordination of air and rail facilities is evident, in order that advantage may be taken of the time-saving features of the air lines and the wide distribution of traffic of all sorts which can be secured only through the use of the railroads. Six air lines have scheduled air-rail connections. These connections are made at Cleveland, Columbus, Dallas, Fort Worth, Detroit, Miami, Kansas City and Portland, Oregon, and permit a traveler to reach his destination by a combination of air and rail facilities. This is shown in greater detail on tabulation appended hereto. At Columbus, the airport (Port Columbus) adjoins the railroad station; at Miami the Air Line provides scheduled ground transportation between the airport and the rail station; at Dallas the Air Line provides for ground transportation by taxi-cab. At the other points no ground transportation between airport and rail station is provided, it being necessary for the traveler to make use of available means.

A further co-ordination between rail and air facilities is provided at many large cities through scheduled bus or limousine service between rail terminals and airports, without, however, any co-ordination of rail and air schedules.

The most important co-ordination of rail and air services is for mail. The transportation of mail from the postoffice or railroad station to the airport is usually handled by postoffice equipment.

The Railway Express Agency furnishes co-ordinated air-rail express service through contracts with certain air transport lines operating between New York, San Francisco, Los Angeles and Seattle, via Chicago, Omaha and Salt Lake City; also from Chicago to Dallas as well as on certain connecting lines. In this way the Railway Express Agency provides all-air express between points served by the above air lines and a combination of air and rail express to all points in the United States, using their own trucks for pick-up and delivery. At the present time this is the outstanding example of air-rail co-ordination. Certain air lines, other than those having contracts with the Railway Express Agency, have joined together under the name of the General Air Express for handling all-air express matter, using Postal Telegraph Company Messenger for pick-up and delivery at the cities wherever their airports are located. Still other air companies handle

air express in a similar way using the Western Union Telegraph Company for pick-up and delivery. Another combination is through contracts now pending between seven air lines and the Railway Express Agency for handling by rail air express shipments that cannot go forward by plane on account of cancelled or interrupted flights.

The Railway Express Agency started their air express service September 1, 1927, and this has since been extended to cover about 10,000 air miles. A shipper may deliver a package at his store door or home to a Railway Express Agency truck for shipment via air express and it will be delivered by another Railway Express Agency truck at its destination anywhere in the United States through the co-ordination of air and rail facilities. The Railway Express Agency publishes its own tariffs for air express and the through charges are made up by the sum of the individual rail and air tariffs. The ground transportation between airports and the Railway Express Agency's distributing points in the different cities adjoining the airports used is provided by the air lines. Express packages are limited to a weight of 200 lbs., or a combined length and girth of 106 inches, unless special arrangements have been made in advance for larger packages. The contract with the air lines provides that the Air Company shall transport promptly all of the normal amount of express business procured by the Railway Express Agency, and that in the event express matter offered for any particular schedule cannot be carried on that schedule, the remainder will be forwarded on the next available one. In the event, however, that the next available schedule is uncertain on account of heavy movement of mail, accident, weather conditions or other unavoidable conditions, such excess express matter as can be delivered with equal promptness by all-rail express, or combination rail and air express, shall be promptly returned to the Railway Express Agency. Also, if air express is so delayed that it reaches its destination no faster than it would have by all-rail, a refund is made to the shipper for the difference in cost between air express and all-rail express. The volume of air-express handled by the Railway Express Agency now amounts to about 100,000 lb. per annum and is rapidly growing.

(3) Location of Airports in Co-ordination with Railway Facilities

It will readily be realized that the most important factor in co-ordinating rail and air facilities is the time element involved in ground transportation between the rail head and the airport. Unfortunately, from a co-ordination standpoint, railroad stations are usually found in or near the center of the business section of a city while the airport must be located in the wide open spaces where there is sufficient room for landing and taking off of airplanes without obstructions such as buildings and pole lines. The reduction to a minimum of the time required for ground transportation at the beginning and the end of an air trip is of great importance in passenger travel, particularly between cities less than 200 miles apart. For example, an important passenger and mail route between two cities in the east about 175 miles apart by air, operates on the following schedule:

	Hours	*Minutes*
From hotel in city "A" to airport (plane leaving time).....	0	45
Flying time	2	00
From airport to hotel in city "B".......................	0	30
Total time between cities........................	3	15

In this case the time on the ground is 1 hour and 15 minutes, and in the air 2 hours, and with faster planes the flight time would be reduced materially without a corresponding decrease in the time required for ground transportation. It is therefore of great im-

portance to bring the airport and the railroad station as close together as possible, either in location or through quick ground transportation.

There are several ways in which the rail station and the airport may be connected, as follows:

(a) Airport located in direct contact with the railroad station, permitting direct and quick interchange between rail and air. There are now but three examples of this method (see tabulation attached).

(b) Airport located adjacent to the railroad tracks but at a distance from a railroad station suitable as a point of interchange, transportation between the railroad station and the airport being furnished by scheduled rail service. In this case special rail cars would ordinarily be used for ground transportation. It might be necessary to run a short sidetrack into the airport in order to secure close co-ordination. At the present time there are no examples of this method. The disadvantages of this method and of method (a) above, lie in the obstructions to flying caused by rail operations and by pole lines usually found along the railroad right of way, and in some cases in the interference of the special rail service with dense through rail traffic. While a rail connection between the railroad station and the airport could be expected to reduce the time of ground transportation to a minimum, it usually will be found that the expense is materially greater than if highway transportation were used, due to the first cost of special rail equipment and the train crew requirements, and in some cases to necessary signal protection.

(c) Airport and railroad station separated, ground transportation for passengers between the two by means of buses or limousines operating on a published schedule. Ground transportation for mail and express by truck as required. In this method it becomes highly desirable to select highway routes that are well paved and on which fast time can be made. Some companies, formerly using buses, now use seven passenger limousines as better time can be made through dense city traffic with the limousines and it is necessary to operate only a sufficient number of cars to meet the demands of any particular trip. Whether or not the air and rail schedules are co-ordinated the ground transportation should be operated on a published schedule. There are a large number of instances of this sort of hook-up between rail and air facilities as shown on the tabulation attached hereto. In all cases the ground transportation is furnished by the air line, either directly or through contract with bus or limousine operators, but air line tickets are sold either at a railroad ticket window or a special ticket window of the air line, located in the railroad station, and the bus or limousine operates from a convenient point in the railroad station or immediately adjacent to it.

(d) Ground transportation between railroad station and airport provided by the air line through arrangement with Taxi-Cab Companies. Usually the ground transportation is charged for separately.

(e) Air schedules arranged to connect with through train service to certain points, either with or without ground transportation furnished by the air line. Six air lines schedule such connections at eight (8) points.

(4) Design of Airports in Co-ordination with Railroad Facilities

As far as the design of the airport for air service is concerned, no special feature is necessary because of rail co-ordination, and this report does not deal with this feature. The Secretary of Commerce has by law the power to provide for the examination and rating of air navigation facilities available for the use of air craft of the United States, as to their suitability for use. The term "air navigation facility" includes any air port,

emergency landing field, light or other signal structure, radio direction finding facility, radio or other electrical communication facility and any other structure or facility used as an aid to air navigation. Airport rating regulations are published from time to time, the latest at hand being Aeronautics Bulletin No. 16, effective as amended July 1, 1932. It is not obligatory for an air port to apply for a rating unless so required by the laws of the State in which it is situated. The Aeronautics Branch of the Department of Commerce does regulate the interstate carriage of passengers by air from the standpoint of safety of these passengers, and before starting operations it is necessary for an air line to obtain a certificate from the Department of Commerce and this certificate is issued only if the facilities of the air ports to be used are approved by the Department. The bulletin referred to shows the requirements as to landing strips and it will be noted that for a "T" rating (transport rating) a considerable area is required.

An airport co-ordinated with rail facilities need provide for its rail passengers only those facilities required for all-air passengers, that is, a waiting-room and ticket office where passengers may be received and put on planes in the quickest possible time. For handling mail and express interchange it is only necessary to provide for bringing the trucks close to the plane side. If the air and rail facilities are located in direct contact, as in method 3 (a), it should be possible for passengers to walk from the rail station to the airport office and plane leaving point in a minimum of time. If a sidetrack is run into the airport, as under method 3 (b), again it is important to have the rail discharging point immediately adjacent to the airport office and loading point for planes. If the ground transportation is by automobile, the cars should discharge their passengers directly at the airport waiting-room. Tickets usually must be inspected before passengers board a plane and it is necessary to provide porters to handle and weigh baggage.

At a railroad station co-ordinated with an airport, as under 3 (a), (b) and (c), (scheduled ground transportation being furnished), tickets should be sold at the ticket windows; an "usher" or "conductor" will be required, particularly under method (c), to check passengers' baggage and see that the passengers are loaded into whatever conveyance is provided for ground transportation. At large rail terminals, where ground transportation is by automobile, a convenient loading place must be provided with a porter to handle and stow away the baggage. This loading point should preferably be under cover and as near as possible to the ticket window.

(5) Advantages to be derived from Air-Rail Co-ordination

Except for a limited number of rail-air connections, there is now no co-ordination of schedules to permit quick through service by means of the two methods of passenger travel. Each facility, air and rail, is organized entirely independent of the other and the air lines do not have the advantage of the close cooperation that exists between the railroads. The complaint of the air traveller today is that he does not have information available which will tell him how he can get to his destination in a minimum of time by the use of existing air and rail facilities, and that due to the recognized uncertainty of air schedules, due to weather conditions, he may find his journey interrupted or delayed to the extent that he would have made much better time by all-rail. If there is to be any widespread use of air facilities, other than for flights between important cities where there is sufficient air travel to support such lines, the railroads must be used for a portion of the journey and it should be possible for a passenger to lay out his trip in advance and know that connections between rail and air facilities can be made without undue delay, or, in case flying must be interrupted due to bad weather, to know this a reasonable time in advance of reaching the airport so that he can replace his air trip

with a rail trip without undue delay. The railroads are in the best position to provide co-ordinated service because of their terminal facilities and organization. For example, through such co-ordination a passenger may be told in advance whether or not the plane on which he has engaged a seat will fly and in case the flight cannot be made he can be put on a train for a part or the whole of his journey without the inconvenience of arriving at the airport only to find that the flight will not be made. The present uncertainties of air travel, because of weather conditions, are shown by the fact that at one airport in the east only 75 per cent of the scheduled flights were made during the year 1931. At another airport, more favorably situated in respect to weather, 90 per cent of the scheduled flights were completed during the year ending July 2, 1932.

The best example today of air-rail co-ordination is that of the Railway Express Agency, and similar service which will permit passengers to make free use of both methods of travel would be a distinct advance in the art of transportation.

CO-ORDINATION OF AIR AND RAIL FACILITIES FOR PASSENGER SERVICE

(a) Direct Air to Rail Interchange

PORT COLUMBUS, OHIO, on the Pennsylvania Railroad.

American Airways Inc., Central Division, on route Nashville–Cleveland.

Transcontinental & Western Air Inc., on routes, Amarillo–Columbus, Kansas City–New York and Columbus–Chicago.

MILWAUKEE MUNICIPAL AIR-MARINE TERMINAL—MILWAUKEE, WIS., Chicago & Northwestern Railway Station adjacent thereto.

Kohler Aviation Corp., on routes, Milwaukee–Grand Rapids, Lansing and Detroit.

DUDLEY WATERS CASSARD AIRPORT, GRAND RAPIDS, MICH., on the Michigan Central Railroad.

Kohler Aviation Corp., on routes, Milwaukee–Grand Rapids and Detroit–Grand Rapids.

(b) Rail Terminal and Airport Connected by Special Rail Service

None under this classification at the present time.

(c) Rail Terminal and Airport Connected by Bus or Smaller Automobiles Running Under Definite Schedules to Connect with Air Service

NEWARK AIRPORT, NEWARK, N. J.

American Airways Inc., Colonial Division, on routes, New York–Boston and New York–Albany.

Chartered car transports passengers between the Hotel Commodore adjacent to the Grand Central Terminal, N. Y. C. R. R., New York City and the Airport.

Eastern Air Transport Inc., on routes, New York–Atlantic City, New York–Miami and New York–Jacksonville.

Buses leave 32nd Street entrance of the Pennsylvania Hotel directly opposite the Pennsylvania R. R. Station, New York City, 45 minutes before plane departure for the Airport.

Ludington Airlines Inc., on route, Washington–New York.

Cars leave the Pennsylvania R. R. Station in New York City on the hour from 7 AM to 6 PM for the Airport and arrive at the Pennsylvania R. R. Station in New York City, hourly from 10:40 AM to 8:40 PM from the Airport. This service is supplied by a local car renting concern for the Ludington Co.

Martz Airlines, on route, New York–Buffalo.

Martz Airlines' bus leaves 32nd Street, entrance of the Pennsylvania Hotel, directly opposite the Pennsylvania Railroad Station in New York City, 45 minutes before plane departure, for the Airport.

Transcontinental & Western Air Inc., on route, New York–Kansas City.

Chartered limousine departs from the Pennsylvania Railroad Station in New York City, one hour prior to plane departure, for the Airport.

LOGAN FIELD, BALTIMORE, MD.

Ludington Airlines Inc., on route, Washington–New York, Ludington car leaves Pennsylvania R. R. City Ticket Office, on the hour for the Airport.

MUNICIPAL AIRPORT, CHICAGO, ILL.

Transcontinental & Western Air Inc., on route, Columbus–Chicago.

Airline Motor Coach Co., car leaves Travel Shop of the Pennsylvania Railroad, 334 N. Michigan Ave., Chicago, Ill., one hour before scheduled departure of planes, for the Airport.

PAN AMERICAN SEAPLANE BASE, DINNER KEY, FLA.
MUNICIPAL AIRPORT, BROWNSVILLE, TEX.

Pan American Airways Inc., on routes, Miami–West Indies–Central and South America and Brownsville–Mexico–Central America.

At Miami transfer of passengers is made from train to plane through the use of specially constructed aero-cars (trailers hitched to passenger autos) which meet the trains. Air-rail connection is made with a Florida East Coast Railway train to and from Jacksonville, Cincinnati, St. Louis, Detroit, Cleveland and Chicago.

At Brownsville, passengers are transported between the Southern Pacific and Missouri Pacific R. R. Station and the Airport, in Pan American cars.

ENGLISH FIELD, AMARILLO, TEX.
AIR MAIL FIELD, EL PASO, TEX.
MUNICIPAL AIRPORT, CHEYENNE, WYO.

Western Air Express, on routes, Cheyenne–El Paso and Pueblo–Amarillo.

Bus service is available between the railroad stations and the airports.

(d) Ground Transportation Between Rail Station and Airport Provided by the Air Lines Through Arrangement with Taxi-Cab Companies

HARRISBURG AIRPORT, HARRISBURG, PA.

Transcontinental & Western Air Inc., on route, Kansas City–New York.

Cab departs from the Pennsylvania R. R. Station in Harrisburg, for the airport. No set schedule.

MUNICIPAL AIRPORT, CHICAGO, ILL.
MUNICIPAL AIRPORT, IOWA CITY, IOWA.
MUNICIPAL AIRPORT, DES MOINES, IOWA.
MUNICIPAL AIRPORT, OMAHA, NEBR.
MUNICIPAL AIRPORT, LINCOLN, NEBR.
MUNICIPAL AIRPORT, NORTH PLATTE, NEBR.
STEVENS FIELD, ROCK SPRINGS, WYO.
KEDDIE FIELD, ELKO, NEV.
HUBBARD FIELD, RENO, NEV.
MUNICIPAL AIRPORT, SACRAMENTO, CAL.
RICKENBACKER FIELD, SIOUX CITY, IOWA.
....................SIOUX FALLS, S. D.
....................WATERTOWN, S. D.

Boeing Air Transport Inc., on routes, San Francisco–Chicago and Omaha–Watertown.

Passengers are transported between airports and railroad stations. This service is supplied by the Boeing Air Transport.

FAIRFAX AIRPORT, KANSAS CITY, MO.

Braniff Airways Inc., on route, Oklahoma City–Kansas City.

Passengers are transported between the Union Depot in Kansas City and the airport. This transportation is supplied by the Braniff Airways.

MUNICIPAL AIRPORT, TULSA, OKLA.
LOVE FIELD, DALLAS, TEX.
WINBURN FIELD, SAN ANTONIO, TEX.

Bowen Air Lines Inc., on routes, Dallas–Fort Worth–Tulsa and San Antonio–Fort Worth.

Passengers are transported between the Frisco Station in Tulsa and the Municipal Airport—the Missouri Pacific—Texas Pacific and Kansas Railroad Stations in Dallas and Love Field—the Missouri Pacific Station in San Antonio and Winburn Field. This transportation is supplied by various cab companies which have arrangements with the Bowen Air Lines.

At Dallas, Texas, air-rail connection is made with M. K. & T. Line trains from San Antonio, Texas, and Houston, Texas.

MUNICIPAL AIRPORT, CHEYENNE, WYO.

Western Air Express, on route, San Diego–Seattle.

Passengers are transported between the railroad station in Cheyenne and the airport. This transportation is supplied by the Western Air Express, which have arrangements with Cab Company.

GLENDALE AIR TERMINAL, LOS ANGELES, CAL.

Gilpin Air Lines, on route, Agua Caliente–Los Angeles via San Diego.

Passengers are transported between the Southern Pacific Station in Glendale or to the Southern Pacific or Santa Fe Stations in Los Angeles and the airport. This transportation is supplied by a cab company under contract with the Gilpin Air Lines.

LINDBERGH FIELD, SAN DIEGO, CAL.

Gilpin Air Lines, on route, Agua Caliente–Los Angeles via San Diego.

Passengers are transported between the railroad station in San Diego and the airport. A taxi concern supplied this transportation for the Gilpin Air Lines.

MUNICIPAL AIRPORT, DENVER, COLO.
MUNICIPAL AIRPORT, COLORADO SPRINGS, COLO.
MUNICIPAL AIRPORT, PUEBLO, COLO.
T. & W. A. AIRPORT, ALBUQUERQUE, N. M.
AIR MAIL FIELD, EL PASO, TEX.
ENGLISH FIELD, AMARILLO, TEX.

Western Air Express, on routes, Cheyenne–El Paso and Pueblo–Amarillo.

Passengers are transported between the railroad stations and the airports. This transportation is supplied by various cab companies which have arrangements with the Western Air Express.

(e) Air Schedules Arranged to Connect with Through Train Service to Certain Points

MUNICIPAL AIRPORT, CLEVELAND, OHIO.
PORT COLUMBUS, COLUMBUS, OHIO.

American Airways Inc., on route, Boston–New York–Dallas–Fort Worth–Los Angeles–San Diego.

At Cleveland, Ohio, air-rail connection is made with the N. Y. C. R. R. train to and from New York, Boston, Albany, Springfield and Hartford.

At Port Columbus, Ohio, air-rail connection is made with the Penn. R. R. train to and from New York, Newark, Washington, Baltimore, No. Philadelphia, Harrisburg and Pittsburgh.

LOVE FIELD, DALLAS, TEX.
MUNICIPAL AIRPORT, FORT WORTH, TEX.

Bowen Air Lines Inc., on route, Tulsa–Oklahoma City–Dallas–Fort Worth–Houston–Austin–San Antonio.

At Dallas, Texas, air-rail connection is made with M. K. & T. Line trains from San Antonio, Texas, and Houston, Texas. Passengers are transported between Love Field and the M. K. & T. Ry. station in Dallas. This transportation is supplied by a Cab Company which has arrangements with Bowen Air Lines.

At Fort Worth, Texas, air-rail connection is made with night trains for east, west and south Texas. No ground transportation is furnished.

KOHLER AVIATION CORP., AIR MARINE TERMINAL, DETROIT, MICH.

Kohler Aviation Corp., on route, Milwaukee–Grand Rapids–Detroit.

At Detroit, Mich., air-rail connection is made with Michigan Central Railroad trains to and from New York, Buffalo and Boston. No ground transportation is furnished.

PAN AMERICAN SEAPLANE BASE, DINNER KEY, FLA.

Pan American Airways Inc., on route, Miami–Cuba–Mexico–Central America–South America.

At Miami, Fla., Air-Rail connection is made with a Florida East Coast Ry. train to and from Jacksonville, Cincinnati, St. Louis, Detroit, Cleveland and Chicago. Transfer of passengers is made from train to plane through the use of specially constructed aerocars (trailers hitched to passenger autos) which meet the trains.

MUNICIPAL AIRPORT, KANSAS CITY, MO.

Transcontinental and Western Air Inc., on route, Chicago–Los Angeles.

At Kansas City, Mo., air-rail connection is made with trains to and from Chicago. No ground transportation is furnished.

MUNICIPAL AIRPORT, CLEVELAND, OHIO.

National Air Transport Inc., (United Air Lines), on route, New York–Chicago.

At Cleveland, Ohio, air-rail connection is made with a N. Y. C. train to and from New York. No ground transportation is furnished.

MUNICIPAL AIRPORT, PORTLAND, ORE.

Varney Air Lines Inc., (United Air Lines), on route, Seattle–Portland–Pasco–Salt Lake City.

At Portland, Ore., air-rail connection is made with Northern Pacific night train from Seattle and Tacoma, for passengers destined for Chicago, Cleveland or New York. No ground transportation is furnished.

Appendix E

(9) SCALES

M. J. J. Harrison, Chairman, Sub-Committee; J. E. Armstrong, A. Bousfield, A. W. Epright, L. W. Fuller, E. D. Gordon, E. M. Hastings, H. O. Hem, E. K. Lawrence, H. L. Ripley, H. M. Roeser, E. P. Vroome.

As a part of its current report, your Committee is recommending a revision of a part of Section VI—Test Weight Cars, of the "Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales" (pages 1032–1034, 1929 Manual). With a view to revising the remainder of this Section at some future time, thereby bringing the entire Section up to date, your Committee herewith submits—

(a) Rules for the Maintenance and Transportation of Track Scale Test Weight Cars.

(b) Definition of a Standard Test of a Railway Track Scale.

Preliminary work incident to the preparation of this material was performed by and under the auspices of the National Scale Men's Association, and members of your Committee were actively identified with such work. Since approval of this material by its

originating association, both the "Rules" and the "Definition" have been critically reviewed by your Committee, and revised in some details. In their revised form, the "Rules" and the "Definition" are herewith presented as information.

RULES FOR MAINTENANCE AND TRANSPORTATION OF TRACK SCALE TEST WEIGHT CARS

Foreword

The purpose of these rules is to establish uniform practice in the maintenance and transportation of track scale test weight cars, to the end of securing uniformity in the quality of track scale test results. The rules are intended to cover all phases of test weight car operation except those incident to testing technic. They are applicable to all cars intended to be maintained at a definite weight, and which are used as standards of mass in testing track scales in either railway or industrial service. For brevity, such cars will be designated subsequently throughout these rules as "Test Weight Cars".

1. Classification

The circumstances of use require that test weight cars be classified into two major groups, namely, "Road Test Weight Cars" and "Terminal Test Weight Cars".

(a) Road test weight cars are those required by the circumstances of use to be handled normally in road-haul movements over a considerable territory, in the course of which interchange rules may become applicable.

(b) Terminal test weight cars are those whose field of use is normally within the switching limits of a given locality.

(Note.—The distinction between (a) and (b), above is ordinarily but not necessarily one of ownership. Railway owned test weight cars will be usually within the first class, and industrially owned cars in the second. Attention is directed to the fact that interchange rules do not require air-operated brakes on test weight cars.)

2. Weight Control

(a) General.—All test weight cars are required to be maintained accurately to their designed or nominal weight values. For this purpose, each car shall be verified and corrected as often as may be required, by comparison with the standards of the United States on a scale designated as a master scale by the National Bureau of Standards. A test weight car shall be considered unsatisfactory as a standard of mass when its actual weight differs from the nominal weight value by more than sixteen (16) pounds in excess or deficiency.

(Note.—The foregoing paragraph is intended for literal application within the United States. Within the Dominion of Canada and the Republic of Mexico, it should govern as to permissible limits of variation unless modified by existing law or Governmental regulation.)

(b) Responsibility for Weight Control.—The scale inspector in charge of each car shall be responsible for its weight control in the interval between successive verifications. It shall be his duty to supervise all repairs and recommend advisable modifications, in addition to and in anticipation of M.C.B. Rules. He shall personally weigh all parts removed and materials added when minor repairs are made enroute between verifications. He shall either attend personally to lubrication or supervise it. Since lubrication is an important factor in weight control, varying in degree with different cars, he shall, with due regard for the requirements of each case, take necessary measures to maintain an adequate supply of lubricant and to keep the weight of the car within the prescribed limits of variation.

(c) Frequency of Verification Recommended.

(1) The frequency required for verifications of a given test weight car will depend upon circumstances of use. Generally, road cars will require verification more frequently than terminal cars. The normal frequency required for any particular case can be determined only by experience.

(2) Road test weight cars, which cover definite territory periodically, should be verified at the beginning and end of each itinerary. If the interval between the end of one itinerary and the beginning of the next is reasonably short, the verification which

would normally precede the next itinerary may be omitted. This recommendation presumes that each itinerary can ordinarily be completed without the weight variations resulting from normal use being in excess of the allowable variation.

(3) Except in special cases where facilities for local control are exceptionally good, twice yearly should be considered the minimum frequency for verification of terminal test weight cars.

(d) VERIFICATION FOLLOWING REPAIRS.—Any test weight car should be verified following major repairs for damage or wear, and following repairs or alterations of any kind which involve weight changes that cannot be confidently controlled by weighing material removed and applied.

(e) CLASSIFICATION OF REPAIRS.—Repairs to test weight cars may be classified as either major repairs or minor repairs.

(1) Major repairs are those of such nature and extent that, following their completion, verification of the test car weight is required to establish its suitability for use. They include removal and/or repair and/or replacement of wheels, axles, roller bearing assemblies, journal boxes, draft gear and couplers; replacement of lost or destroyed parts whose weight is unknown or whose replacement is likely to cause a weight variation greater than that allowable; repairs of a general nature subsequent to damage by derailment, collision, or the like; and painting.

(2) Minor repairs may include lubrication, and replacement of bolts, nuts, grab irons, air hose, air hose fittings, knuckles, brake rigging, journal brasses, springs, or other parts which either are of known weight or can be weighed on removal and replaced with parts of known weight.

(3) Record of Repairs.—A historical record describing the nature of all repairs should be maintained. When minor repairs are made and the weight control is maintained by weighing the material removed and applied, the record should itemize parts and weights.

(f) SEMI-ELLIPTICAL SPRINGS.—If a test weight car is equipped with semi-elliptical springs, each spring, when installed, should have its weight stamped or otherwise permanently marked on the band. If spare springs are carried, each should be marked with its weight.

(g) AIR EQUIPMENT.—Test weight cars equipped with air-operated brakes should have the equipment inspected, cleaned, repaired if necessary, lubricated and stenciled at the time of verification. In any event, such work must be done at such periods that expiration of the interval allowed as a maximum by M.C.B. Rules for operation without reinspection will not occur while a car is on a testing trip.

(h) REMOVING FOREIGN MATERIAL.—Test weight cars carrying accumulations of snow, ice or sleet must not be used. Frozen matter may be removed by placing the car in a heated building or by using steam, but not by the use of salt or chemicals. Oil and dirt on the car wheels should be removed by suitable means. Accumulated moisture in closed compartments must be removed whenever circumstances require.

(NOTE.—All compartments and recesses should be made self-draining.)

(i) PAINTING.—Test weight cars should be kept well painted. The finish should have a gloss that can be restored by applying available forms of vehicle polish. Chipped portions of the paint surface should be retouched at times of verification.

(j) SURPLUS LADING.—Articles such as car movers, tools, tool boxes, personal effects, etc., must not be included in the nominal weight of a test weight car. One metal chock per car may be so included.

(k) INSPECTION PRECEDING TEST.—Test weight cars must be examined by the inspector in charge immediately before each test, with a view to detecting damaged or missing parts or the unauthorized substitution of parts.

(NOTE.—A common operating difficulty is the making of running repairs, such as replacement of brake shoes, knuckles, air fittings, etc., without notification to the scale inspector who is responsible for weight control. It can be offset only by strict vigilance and discipline.)

(l) DATE OF LATEST VERIFICATION.—This shall be stenciled on both sides of the car.

3. Transportation

YARD HANDLING.—Test weight cars should be protected from rough handling at all times. Those equipped with roller bearings should not be "humped" without warning

against runaways to the hump foreman and switching crews. Impacts at greater speeds than two miles an hour should be avoided. When uncoupled from a train or cut of cars in motion, the brakes should be manned and, after motion has stopped, firmly set.

DEFINITION OF A STANDARD TEST OF A RAILWAY TRACK SCALE

1. Test Equipment.—A Standard Test Car, as the term is used herein, is a Test Weight Car which is constructed, operated and maintained according to the applicable specifications and rules adopted by the American Railway Engineering Association.

2. Test Car Positions.—The sections of a railway track scale are numbered 1, 2, 3, etc., from left to right when standing at the weigh-beam and facing the scale deck. Normal positions of a test car are designated in order from left to right as—1R, 2L, 2, 2R, 3L, 3, 3R, etc., the numbers representing the sections and the letters, when affixed, indicating that the body of the car lies to the left or right of the section with one pair of wheels directly over the section. The following are standard combinations of normal test car positions (taking a four-section scale as an example), any one of which combinations may be used when making a standard track scale test:

(a) 1R, 2, 3, 4L.
(b) 1R, 2L, 3R, 4L.
(c) 1R, 2L, 2R, 3L, 3R, 4L.

When testing end sections, the test car shall be spotted as near as practicable to the end of the scale rails. When testing a two-section scale, the standard combination of normal test car positions is:

1R, Center, 2L.

3. Zero Load Balance.—Any out-of-balance condition of the scale shall be noted by the scale inspector upon his arrival, and the amount thereof be recorded on the report form. After correcting the out-of-balance condition, if any, and before any adjustment or repairs are made, the scale shall be tested as outlined herein. The zero load balance shall be checked after each run of each test car across the scale, and any out-of-balance condition thus found shall be corrected, and the amount thereof shown on the test report. This correction shall be made by moving the balance ball or other balancing accessories of the weigh-beam. The scale indications shall be read to the nearest 10 lb., and the several readings shall be so recorded on the report form as clearly to indicate that they represent the weighing condition of the scale "as found" or "as left".

4. Sensibility-Reciprocal.—The sensibility-reciprocal (SR) is the change in load required to turn the weigh-beam from a horizontal position of equilibrium in the center of the trig loop to a position of equilibrium at either limit of its travel. In the case of track scales, the construction of which includes a weigh-beam and multiplying indicator connected thereto, the condition of balance of which is shown by the position of the indicator with reference to the center of a series of graduations, and where the total movement of the indicator exceeds one-half inch, the SR is the change in load required to move the indicator tip one-fourth inch from its normal position of balance to a new position of equilibrium.

5. Classification of Tests.—Standard track scale tests are classified as follows, according to the character of testing equipment used:—

Standard Graduated Test.—A standard graduated test is one made with two standard test cars weighing, respectively, not less than 30,000 lb. and not less than 80,000 lb. The weight of the light car should approximate one-half the weight of the heavy car. The standard test procedure is as follows:—

(1) Spot one test car at each of the predetermined test positions, and record both the scale indication and the error for each such position.

(2) Spot the other test car at each of the predetermined test positions, and record both the scale indication and the error for each such position.

(3) Spot both test cars on the scale rails, separated by such distance or distances as will result in a condition of loading approximately equivalent to that produced by a freight car, and record the positions, the scale indication, and the error.

(4) Inspect scale, remove binds, do any practicable repair work, and make any advisable adjustments.

(5) If any defective condition is corrected or any adjustment made, repeat tests Nos. 1, 2 and 3, reversing the positions of the cars in test No. 3 when practicable.

SINGLE-LOAD TEST—STANDARD FORM.—The standard form of single-load test is one made with one standard test car, the weight of which is not less than 80,000 lb. The standard test procedure is as follows:—

(1) Spot test car at each of the predetermined test positions, and record both the scale indication and the error for each such position.

(2) Inspect scale, remove binds, do any practicable repair work, and make any advisable adjustments.

(3) If any defective condition is corrected or any adjustment made, repeat test.

SINGLE-LOAD TEST—SECONDARY FORM.—The secondary form of single-load test is one made with a test car, the weight of which is less than 80,000 lb. and/or the length of whose wheelbase exceeds seven feet. The test procedure is the same as that for the standard form of single-load test, but the test report must clearly indicate the weight of the test car and the length of its wheelbase.

6. SCALES WITH AUTOMATIC WEIGHT RECORDING ATTACHMENTS.—For scales equipped with automatic weight recording attachments, the test procedure specified herein should be followed with the attachment connected. If the errors found in this test exceed the tolerance applicable, or if routine use is made of the scale from time to time with weigh-beam only, the attachment shall be disconnected, the weigh-beam balanced, and the complete test procedure repeated. If the errors now found exceed the tolerances applicable, corrective adjustments shall be made to the scale proper, whereupon the automatic attachment shall be reconnected and the complete test procedure repeated. If the errors now found exceed the tolerances applicable, corrective adjustments shall be made to the automatic attachment. In no case shall any adjustment be made to the lever system of a track scale to correct for inaccuracy shown by the test to be contributed by the automatic attachment, or vice versa. The scale and automatic attachment must be individually correctly adjusted.

7. TEST RECORD.—The results of the test shall be recorded during the course thereof on a suitable report form. The following information shall be shown:—

(a) Date of test and signature of inspector.

(b) Full and complete identification of the scale.

(c) Classification of test, as determined hereby.

(d) Identification, nominal weight, and length of wheelbase of each test car used.

(e) Balance condition and SR as found by the inspector upon his arrival.

(f) Results of test before any adjustment or repairs are made, with readings and errors to the nearest 10 lb.

(g) The amount of change in zero load balance after each run of each test car or cars across the scale.

(h) The value of the SR under zero load and under maximum applied load.

(i) Any defective condition found during inspection of the scale.

(j) Any adjustment made to correct the weighing performance of the scale.

(k) Any action taken at the time of the test to correct defective conditions found to exist in the scale mechanism or structure.

(l) Results of test after making adjustment or correcting any defective condition in the scale mechanism or structure, with readings and errors to the nearest 10 lb.

(m) Recommendations of the inspector, unless these are required to be made separately.

(n) Any additional information required by the testing agency, and any unusual condition affecting the test.

8. TOLERANCES.—Every track scale should be kept in the closest possible adjustment, and the weighing performance should be considered unsatisfactory when the scale is not maintained within the appropriate tolerance as herein set forth.

The formally adopted tolerances to be allowed in excess or deficiency on all track scales except grain-weighing track scales are as follows:—

(1) MANUFACTURERS' TOLERANCE.—The manufacturers' tolerance to be allowed on the first field test, after installation corrections, of all new railway track scales shall not exceed 1/20 of 1 per cent, or 50 lb. per 100,000 lb., for any position of the test car load on the scale. The minimum test car load to be applied shall be 30,000 lb.

The SR shall not exceed 50 lb.

(2) MAINTENANCE TOLERANCE.—The maintenance tolerance on track scales in commercial weighing service shall be—

(a) 2/10 of 1 per cent, or 2 lb. per 1000 lb. of test load, when one test car of seven-foot wheelbase or less is used, the tolerance to be applied to the largest mean of two errors found for different positions of the car not closer than similar positions on adjacent spans. In no case shall the error at any position exceed 3/10 of 1 per cent, or 3 lb. per 1000 lb. of test load.

(b) 2/10 of 1 per cent, or 2 lb. per 1000 lb. of test load, when two standard test cars are applied on the scale at the same time and at positions not closer together than similar points on adjacent spans.

(c) 2/10 of 1 per cent, or 2 lb. per 1000 lb. of test load, when the wheelbase of the test car exceeds seven feet.

(d) 2/10 of 1 per cent, or 2 lb. per 1000 lb. of test load, on two-section scales.

The SR shall not exceed 100 lb.

(2-a) Maintenance Tolerances on Track Scales Equipped with Automatic Indicating or Weight Recording Devices.—When a track scale is equipped with an automatic indicating or weight recording attachment, and test is made with such attachment properly connected to the scale mechanism, the tolerances then to be allowed on the indications of the attachment shall be those specified herein for application when no attachment is used: Provided, however, That the minimum tolerance to be applied in such cases shall be the value of one of the minimum graduations. And provided further, That when the mechanism of the automatic attachment is displaced from its position of equilibrium, with a given load spotted on the scale rails, and then permitted to resume its position of equilibrium, the amount by which it fails to return to such position of equilibrium shall in no case exceed the value of one of the minimum graduations.

Tolerance of Grain-Weighing Track Scales.—The "Grain Scale Specifications", published as an appendix to "Rules for the Handling of Bulk Grain in Interstate Commerce and the Filing, Investigation and Disposition of Claims for Loss and Damage incident thereto", issued pursuant to recommendation of the Interstate Commerce Commission, prescribe the following tolerance for grain-weighing track scales:—

"Railroad track scales used for weighing grain shall be maintained so that when a test load, consisting of a one-truck short wheelbase test car, standardized on a master scale, is used, the largest algebraic mean of any two errors found for different positions of the test truck shall not exceed one-tenth of 1 per cent, or one pound per thousand pounds of test load applied; provided, however, that no two errors shall be selected corresponding to positions of the test truck equal to or closer together than the distance between the sections of the scale. Moreover, the scale shall be corrected when it is found, on test, that the error exceeds one-tenth of 1 per cent of the test load applied for any position of the test load on the scale. The manufacturers tolerances on new scales shall be one-half of the above values.

"The sensibility-reciprocal shall not exceed 50 lb. in any case."

Appendix F

(10) BIBLIOGRAPHY OF RAILWAY STATIONS, YARDS, MARINE TERMINALS AND AIR-PORTS

Compiled by E. E. R. Tratman

(A) PASSENGER STATIONS AND TERMINALS

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(E) MISCELLANEOUS

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REPORT OF COMMITTEE XI—RECORDS AND ACCOUNTS

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Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

Group A—Miscellaneous

(1) Revision of the Manual.—The Committee has continued the study of the Manual and the Proceedings for the purpose of revising and bringing to date the material now in the Manual, and perhaps making substitutions from the Proceedings for recommendation. The various Sub-Committees have been aggressive in this field and have presented much data for the consideration of the Committee. In anticipation of a revision of the Interstate Commerce Commission Classification of Accounts, involving Depreciation Accounting, affecting accounting and valuation, the Committee withholds any recommendations or changes at this time. The instant report is one of progress, awaiting developments, and an endeavor will be made to present next year definite recommendations in line with new classifications, including Depreciation Accounting, if issued.

(2) Bibliography on subjects pertaining to Records and Accounts (Appendix A).

Group B—General Railway Engineering Reports and Records

(1) Office and drafting room practices (Appendix B).

(2) Joint facility records:

(a) Appraisal methods and records for keeping up to date.
(b) Maintenance and operation reports and records.
(c) Effect of depreciation accounting (Appendix C).

(3) Bridge inspection report forms, collaborating with Committee VII—Wooden Bridges and Trestles, Committee VIII—Masonry, Committee XII—Rules and Organization, and Committee XV—Iron and Steel Structures.—The Committee was unable to effect complete collaboration this year with other interested committees. Although a number of meetings were held, approval from those concerned has not been secured. It is desired by the other committees that the subject be continued another year, with the thought that a series of reports acceptable to all the collaborators can be obtained.

Group C—Maintenance of Way Reports and Records

(1) Statistical requirements of operating, accounting and other departments with respect to maintenance of way and structures, collaborating with appropriate committees (Appendix D).

(2) System of reports and records required to budget and control maintenance of way expenses (Appendix E).

Bulletin 350, October, 1932.

(3) Forms used by railway water service departments, collaborating with Committee XIII—Water Service and Sanitation (Appendix F).

Group E—Valuation

(1) Methods and forms for gathering data for keeping up to date the valuation and other records of the property of railways, with respect to:

(a) Changes made necessary by government regulations.

(b) Simplicity and practicability of use (Appendix G).

(2) Methods used in recapture proceedings (Appendix H).

Group F—Accounting Practices Affecting Railway Engineering

(1) Changes and revisions in I.C.C. Classification of Accounts.—While the Bureau of Accounts issued a tentative draft of proposed revised classification to a limited number of accounting officers, in the early part of 1932, no action was subsequently taken to indicate the date on which the new classification would be effective. As the proposed classification was not given general distribution, the Committee has made no attempt to review it, and therefore has nothing to report.

(2) Development under I.C.C. Order No. 15100—Depreciation Charges of Steam Railway Companies (Appendix I).

(3) Method for avoiding duplication of effort and for simplifying and co-ordinating work under the requirements of I.C.C. (Appendix J).

(4) Recommended practice to be followed in preparing data for rate and other cases with respect to valuation, allocation of operating and maintenance costs to various zones and allocation of costs to specific services performed (Appendix K).

Action Recommended

(1) That the reports on subjects A-1, B-3 and F-1 be received as information.

(2) That the reports on subjects A-2, B-1, B-2, C-1, C-2, C-3, E-1, E-2, F-2, F-3 and F-4 be received as progress reports.

Respectfully submitted,

THE COMMITTEE ON RECORDS AND ACCOUNTS,

C. C. HAIRE, *Chairman.*

Appendix A

(A-2) BIBLIOGRAPHY ON SUBJECTS PERTAINING TO RECORDS AND ACCOUNTS

A. P. Weymouth, Chairman, Sub-Committee; C. R. Harte, J. T. Powers, D. C. Teal, W. H. Woodbury.

The method followed in compiling this bibliography for the current year was similar to that used in previous years. Each member was assigned certain periodicals to review and report on important articles, and any new books of interest.

There is also included this year a few general items of outstanding interest affecting the railroad situation as a whole.

The following is respectfully submitted as a bibliographical review covering the period from November, 1931, to October, 1932, inclusive.

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(c) Depreciation Accounting

Depreciation Order Postponed, Railway Age, March 26, 1932, p. 540, reports that on March 17, 1932, the I.C.C. announced a postponement of the effective date for one year, viz., to January 1, 1934.

Editorial on the Depreciation Order in Railway Age, May 28, 1932, p. 895, suggests that its legality ought to be contested in the courts, in view of its far-reaching effects on the railroads.

Annual meeting of the R.A.O.A. summarized in Railway Age, Aug. 13, 1932, p. 226, and refers to report presented by Committee on General Accounts containing a resolution sent to the Railway Executives recommending that efforts be made to secure an indefinite postponement of the Depreciation Order.

Appendix B

(B-1) DRAWINGS AND DRAFTING ROOM PRACTICE

Graphical Symbols

D. L. Avery, Chairman, Sub-Committee; R. R. L. Bullard, V. H. Doyle, W. L. Foster, C. A. Knowles, W. M. Ludolph, D. W. Smith, D. C. Teal, G. R. Walsh, A. P. Weymouth.

Your Committee has revised last year's recommendations to include Graphical Symbols (Revision of the Manual). This has been designated item one and included in last year's report which is as follows:

Drawings and Drafting Room Practices

(1) Graphical Symbols (Revision of the Manual).

(2) Classification of and corresponding nomenclature for drawings in accordance with their purpose.

(3) Method of representation of the subject, including arrangement of views and sections.

(4) Use of lines of different kinds and thickness.

(5) Indication of dimensions, tolerances and fits, tapers and slopes and surface or finish.

(6) Symbols for elements.

(7) Indication of materials by cross hatching.

(8) Arrangement of border line, title, parts test, notes changes and revisions.

(9) Method of folding and punching.

(10) Kinds and sizes of letters, figures and symbols.

(11) Scales of reduction and enlargement.

(12) Sizes of drawings and filing cabinets.

(13) Width of rolls of paper and cloth.

(14) Size of drafting equipment and tools.

(15) Specifications of materials to be used for drawings and drafting.

Your Committee has undertaken the revision of the present Symbols shown on pages 745 to 757, inclusive, in the Manual. It has worked with such A.R.E.A. Committees and is using such data prepared by the American Standards Association as comes under the subject assigned them.

The subject has been divided into two parts: (A) Engineering Symbols and Office Practice, and (B) Electrical Symbols and Office Practice, (a) General, (b) Signal.

The first group of Symbols has been prepared and is submitted hereafter as Exhibit 1. This Exhibit comprises nineteen sheets which cover thirty-five subjects. A total of 500 different symbols are shown.

The Committee has not had sufficient time to thoroughly study this subject and submits Exhibit 1 as a progress report only. It recommends that the subject be continued in order that this exhibit may be revised and that the Electrical Symbols may be prepared. The subject will be continued progressively.

Exhibit 1

DRAWINGS AND DRAFTING ROOM PRACTICE

Graphical Symbols

NUMERICAL INDEX

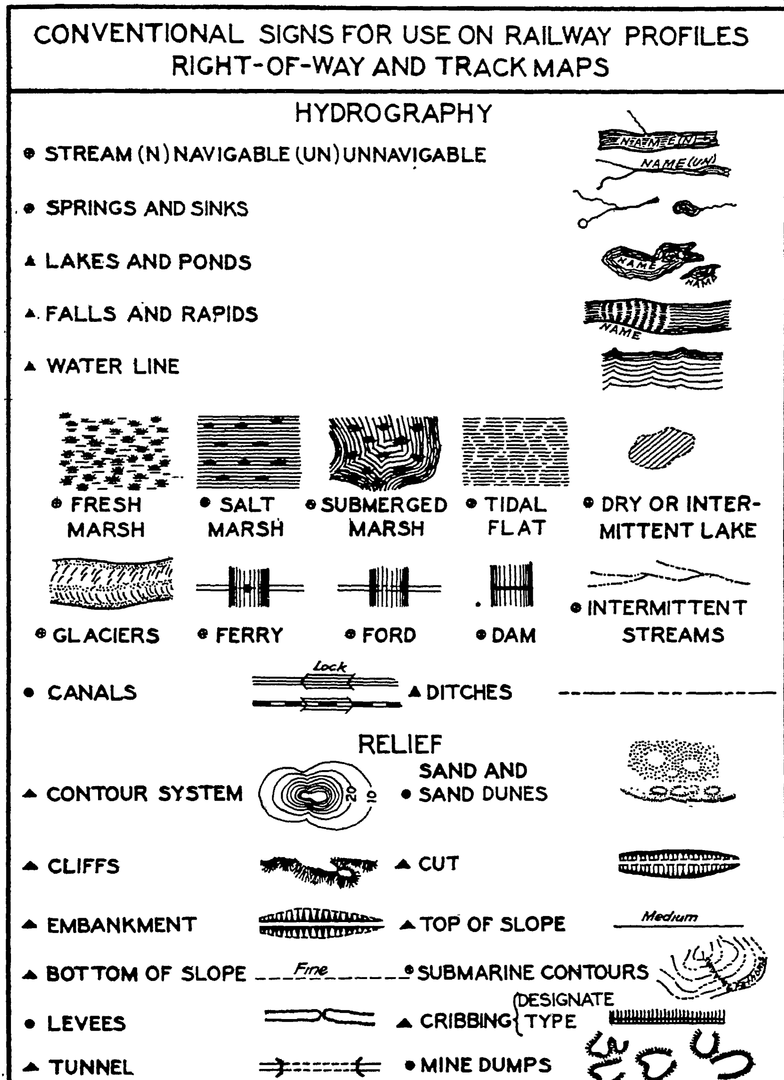
Note.—Page numbers in numerical index refer to the right-hand circular number on pp. 215–233 incl.

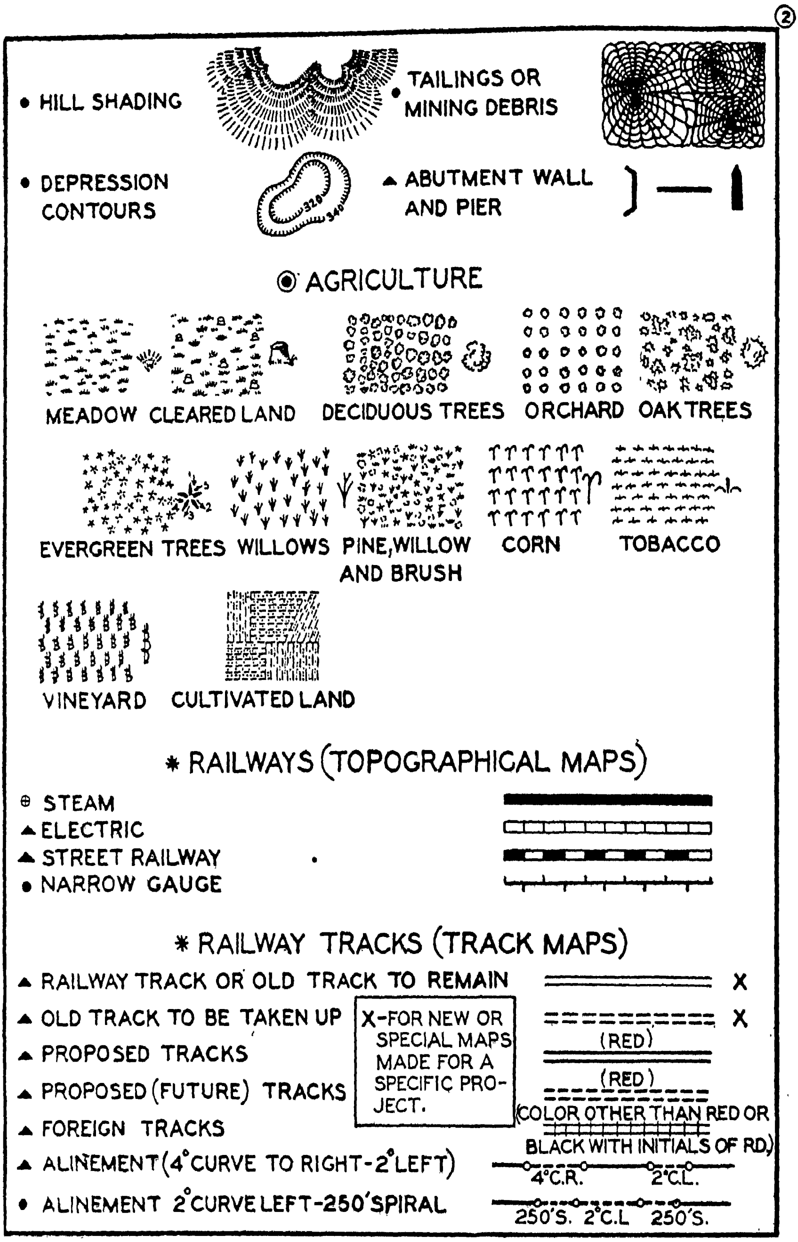
ALPHABETICAL INDEX

EXPLANATION OF CHARACTERS

- ▲ PRESENT A.R.E.A. SYMBOLS
- ⊕ PRESENT A.R.E.A. SYMBOLS REVISED
- ● PROPOSED NEW SYMBOLS
- ◉ PROPOSED NEW SUBJECT

①




②
• HILL SHADING
• TAILINGS OR MINING DEBRIS
• DEPRESSION CONTOURS
320
340
▲ ABUTMENT WALL AND PIER
◉ AGRICULTURE
MEADOW
CLEARED LAND
DECIDUOUS TREES
ORCHARD
OAK TREES
EVERGREEN TREES
WILLOWS
PINE, WILLOW AND BRUSH
CORN
TOBACCO
VINEYARD
CULTIVATED LAND
* RAILWAYS (TOPOGRAPHICAL MAPS)
⊕ STEAM
▲ ELECTRIC
▲ STREET RAILWAY
• NARROW GAUGE
* RAILWAY TRACKS (TRACK MAPS)
▲ RAILWAY TRACK OR OLD TRACK TO REMAIN
X
▲ OLD TRACK TO BE TAKEN UP
X
X-FOR NEW OR SPECIAL MAPS MADE FOR A SPECIFIC PROJECT.
▲ PROPOSED TRACKS
(RED)
▲ PROPOSED (FUTURE) TRACKS
(RED)
▲ FOREIGN TRACKS
(COLOR OTHER THAN RED OR BLACK WITH INITIALS OF RD.)
▲ ALINEMENT (4° CURVE TO RIGHT-2° LEFT)
4°C.R.
2°C.L.
• ALINEMENT 2° CURVE LEFT-250' SPIRAL
250'S.
2°C.L
250'S.

③

- PROFILES (VERTICAL CURVES) +0.1% +0.3% V. C. -0.2% -0.05%

* INDICATES USE OF SINGLE OR DOUBLE LINES FOR RAILWAY TRACK AND YARD STUDIES. DOUBLE LINES ARE SATISFACTORY FOR SCALES OF 1" EQUALS 50' OR LARGER. SINGLE LINE SHOULD BE USED FOR SMALLER SCALES. LINES MAY BE LEFT UNCOLORED.

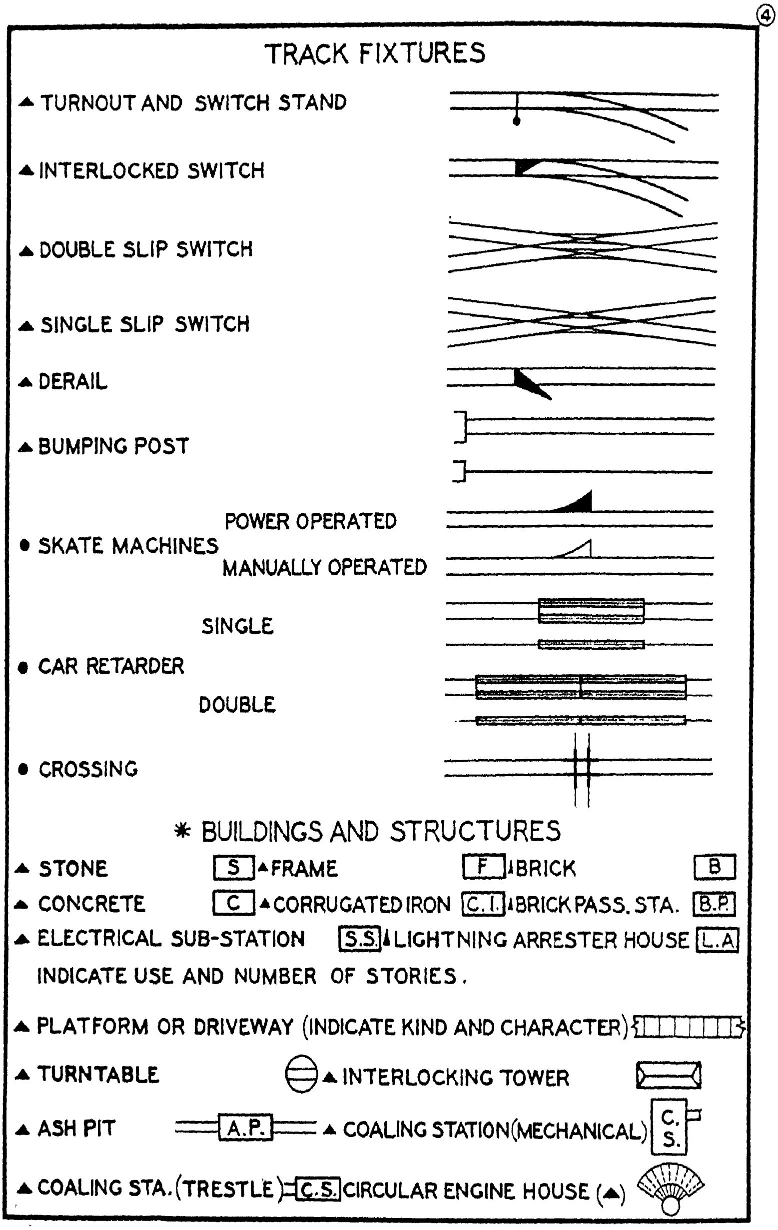
BOUNDARY AND SURVEY LINES

- ● FOREIGN R. OF W. LINE
- ⊕ STATE LINE
- ⊕ COUNTY LINE
- ⊕ TOWNSHIP LINE
- ⊕ CITY OR VILLAGE LINE
- ● RESERVATION LINE
- ● LAND GRANT LINE
- ▲ STREET BLOCK OR OTHER PROPERTY LINE
- ▲ SURVEY LINE — RED
- ▲ CENTER LINE — Original (Track Or Section) Center Line 19. If Monumented, Show Location And Proper Symbol.
- ▲ COMPANY PROPERTY R. OF W. LINE
- ▲ FENCE (ON STREET LINE)
- ▲ FENCE ON RAILWAY PROPERTY LINE

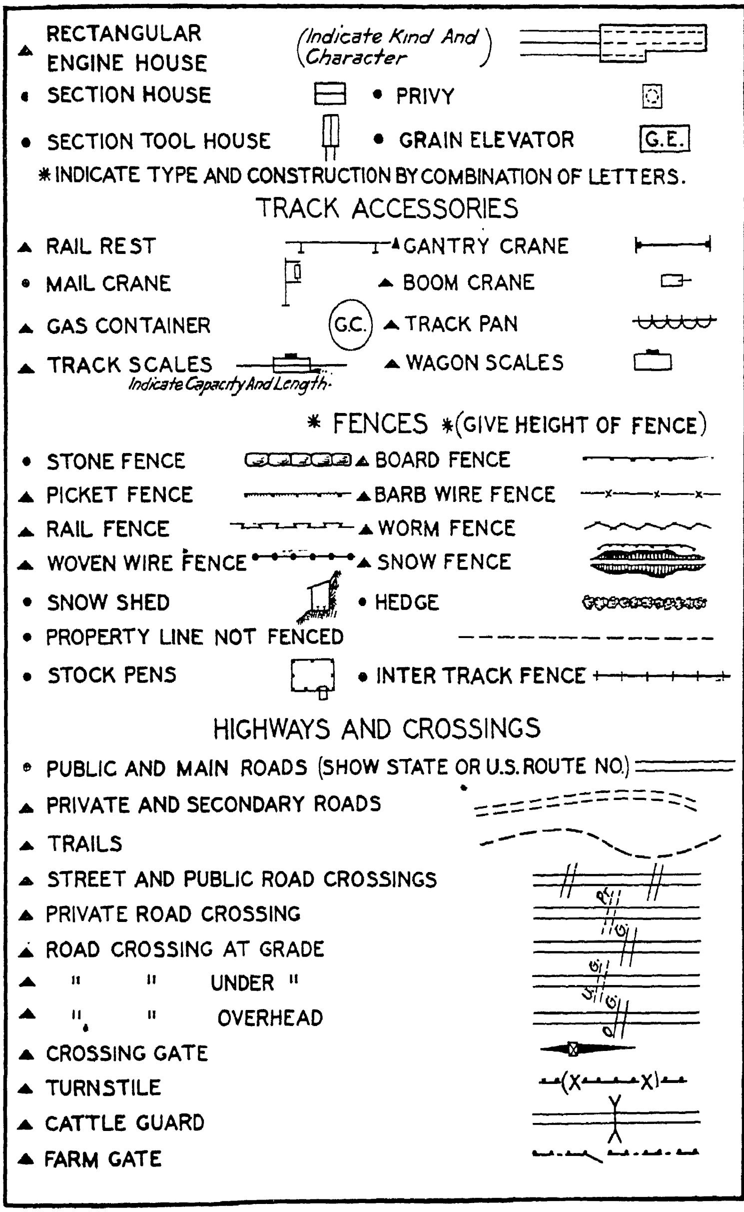
CARTOGRAPHY

- ▲ SECTION CORNER — 17 16 / 20 21
- ▲ SECTION CENTER
- ▲ TRIANGULATION STATION OR TRANSIT POINT
- ▲ BENCH MARK — B.M.X1232
- STONE MONUMENT (▲)
- ▲ IRON MONUMENT
- ▲ CITY
- ▲ VILLAGE
- ▲ CITY LIMITS ★
- ▲ FIRE LIMITS
- ● CEMETERIES — CEM.
- ● CHURCH-SCHOOL
- ● COKE OVENS
- ● TANKS AND OIL RESERVOIRS
- ● OIL AND GAS WELLS
- ● MINE OR QUARRY
- ● PROSPECT — X
- ● SHAFT
- ● MINE TUNNEL
- ● LIGHTHOUSE OR BEACON — ◎
- ● COAST GUARD STATION — L.S.S. C.G.S.
- ▲ MAGNETIC MERIDIAN — N, Variation Angle

★ HATCH OR COLOR (TRANSPARENT) RED

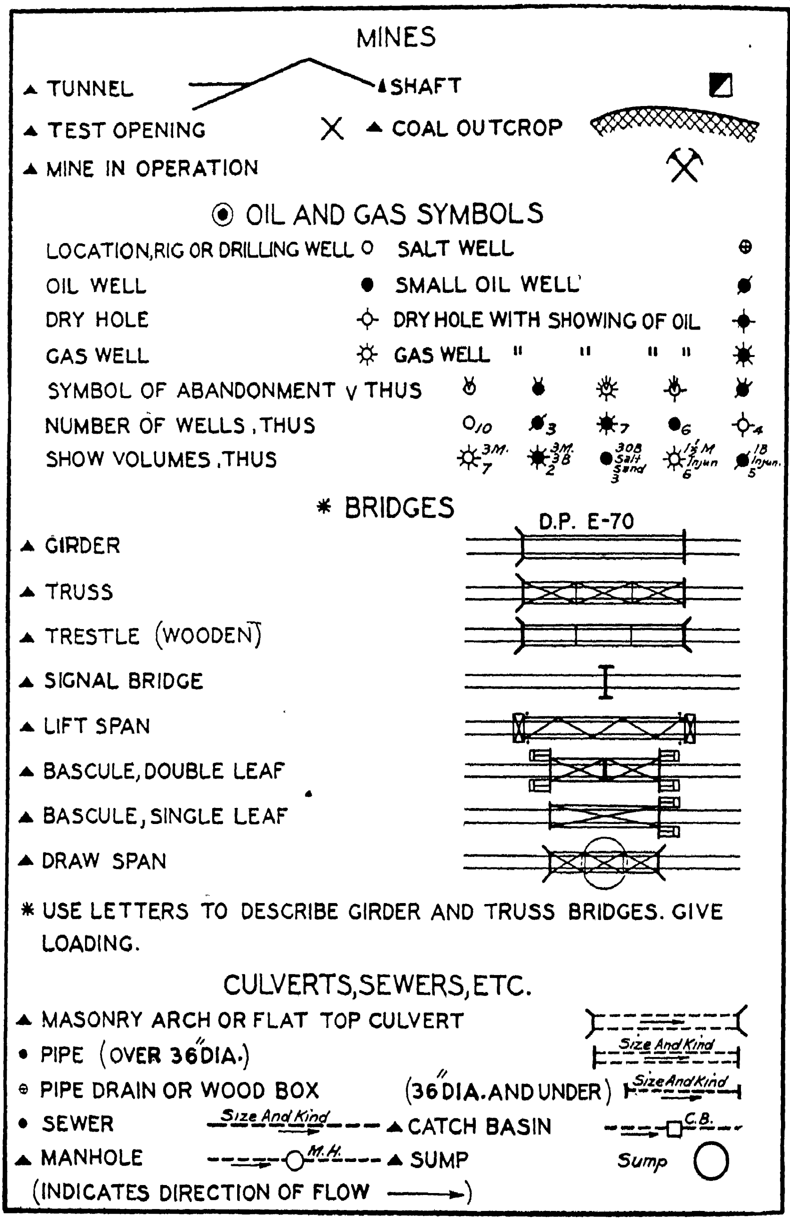

4
TRACK FIXTURES
▲ TURNOUT AND SWITCH STAND
▲ INTERLOCKED SWITCH
▲ DOUBLE SLIP SWITCH
▲ SINGLE SLIP SWITCH
▲ DERAIL
▲ BUMPING POST
● SKATE MACHINES
POWER OPERATED
MANUALLY OPERATED
● CAR RETARDER
SINGLE
DOUBLE
● CROSSING
* BUILDINGS AND STRUCTURES
▲ STONE
S
▲ FRAME
F
▲ BRICK
B
▲ CONCRETE
C
▲ CORRUGATED IRON
C.I.
▲ BRICK PASS. STA.
B.P.
▲ ELECTRICAL SUB-STATION
S.S.
▲ LIGHTNING ARRESTER HOUSE
L.A.
INDICATE USE AND NUMBER OF STORIES.
▲ PLATFORM OR DRIVEWAY (INDICATE KIND AND CHARACTER)
▲ TURNTABLE
▲ INTERLOCKING TOWER
▲ ASH PIT
A.P.
▲ COALING STATION (MECHANICAL)
C. S.
▲ COALING STA. (TRESTLE)
C.S.
CIRCULAR ENGINE HOUSE (▲)

5



RECTANGULAR ENGINE HOUSE
(Indicate Kind And Character)
SECTION HOUSE
PRIVY
SECTION TOOL HOUSE
GRAIN ELEVATOR
G.E.
* INDICATE TYPE AND CONSTRUCTION BY COMBINATION OF LETTERS.
TRACK ACCESSORIES
RAIL REST
GANTRY CRANE
MAIL CRANE
BOOM CRANE
GAS CONTAINER
G.C.
TRACK PAN
TRACK SCALES
Indicate Capacity And Length.
WAGON SCALES
* FENCES *(GIVE HEIGHT OF FENCE)
STONE FENCE
BOARD FENCE
PICKET FENCE
BARB WIRE FENCE
RAIL FENCE
WORM FENCE
WOVEN WIRE FENCE
SNOW FENCE
SNOW SHED
HEDGE
PROPERTY LINE NOT FENCED
STOCK PENS
INTER TRACK FENCE
HIGHWAYS AND CROSSINGS
PUBLIC AND MAIN ROADS (SHOW STATE OR U.S. ROUTE NO.)
PRIVATE AND SECONDARY ROADS
TRAILS
STREET AND PUBLIC ROAD CROSSINGS
PRIVATE ROAD CROSSING
ROAD CROSSING AT GRADE
" " UNDER "
" " OVERHEAD
CROSSING GATE
TURNSTILE
CATTLE GUARD
FARM GATE

⑥


MINES
▲ TUNNEL
▲ SHAFT
▲ TEST OPENING
▲ COAL OUTCROP
▲ MINE IN OPERATION
◉ OIL AND GAS SYMBOLS
LOCATION, RIG OR DRILLING WELL
SALT WELL
OIL WELL
SMALL OIL WELL
DRY HOLE
DRY HOLE WITH SHOWING OF OIL
GAS WELL
GAS WELL " " " "
SYMBOL OF ABANDONMENT V THUS
NUMBER OF WELLS, THUS
10 3 7 6 4
SHOW VOLUMES, THUS
3M. 7
3M. 3B 2
30B Salt Sand 3
1½M Injun 6
1B Injun. 5
* BRIDGES
D.P. E-70
▲ GIRDER
▲ TRUSS
▲ TRESTLE (WOODEN)
▲ SIGNAL BRIDGE
▲ LIFT SPAN
▲ BASCULE, DOUBLE LEAF
▲ BASCULE, SINGLE LEAF
▲ DRAW SPAN
* USE LETTERS TO DESCRIBE GIRDER AND TRUSS BRIDGES. GIVE LOADING.
CULVERTS, SEWERS, ETC.
▲ MASONRY ARCH OR FLAT TOP CULVERT
• PIPE (OVER 36" DIA.)
Size And Kind
⊕ PIPE DRAIN OR WOOD BOX
(36" DIA. AND UNDER)
Size And Kind
• SEWER
Size And Kind
▲ CATCH BASIN
C.B.
▲ MANHOLE
M.H.
▲ SUMP
Sump
(INDICATES DIRECTION OF FLOW)

7

WATER SUPPLY AND PIPE LINES

▲ WATER TANK (GIVE CHARACTER DIAM. HEIGHT CAP. IN GALS.)	W.T.
▲ WATER COLUMN (GIVE SIZE AND TYPE)	
▲ COMPANY (WATER PIPE)	
⊕ OTHER WATER PIPE (GIVE SIZE AND KIND OF PIPE AND DIRECTION OF FLOW)	
• GAS LINE (GIVE SIZE AND KIND OF PIPE AND DIRECTION OF FLOW)	
• STEAM LINE (GIVE SIZE AND KIND OF PIPE AND DIRECTION OF FLOW)	
• OIL LINES (GIVE SIZE AND KIND OF PIPE AND DIRECTION OF FLOW)	
⊕ COMPRESSED AIR	
▲ VALVE (INDICATE SIZE)	V
▲ RISER	R
▲ METER (NAME AND SIZE)	M

FIRE PREVENTION

▲ FIRE HYDRANT (SHOW SIZE, NO. OF HOSE AND STEAMER CONNS.)	H
• FIRE ALARM BOX	F.A.
• CHECK VALVE (ARROW IN DIRECTION OF FLOW)	
• WALL REEL OR HOSE RACK	
• HOSE AND HYDRANT HOUSE	
• FIRE DEPT. CONNECTION	
• AUTOMATIC SPRINKLER	A.S.
• CHEMICAL FIRE EXTINGUISHER { HAND OR WHEEL CARRIAGE	

POLE LINE WIRES

• POWER TRANSMISSION, SIGNAL, TELEGRAPH AND TELEPHONE LINES. (DESIGNATE WIRES & OWNERSHIP)	

ELECTRIFIED LINES

▲ THIRD RAIL	Running Rail Or C.L. Of Track
▲ JUMPERS	Running Rail Or C.L. Of Track; Running Rail Or C.L. Of Track
▲ FEEDER	Feeder; Third Rail
▲ SWITCH	
▲ OVERHEAD RAIL OR WIRE	State Kind

8

LIGHTING

- ELECTRIC LIGHT LOCATION GIVE TYPE OF LAMP AND POWER
- FLOOD LIGHTING TOWER

⦿ RAIL

150LB	BLACK	110LB.	GREEN
140LB.	WHITE	100LB.	ORANGE
130LB	RED	90LB.	BROWN
120LB	YELLOW	80LB	LIGHT BLUE

SOLID LINES OF THE COLORS SHOWN MAY BE USED IN PLACE OF SYMBOLS

⊕ BALLAST

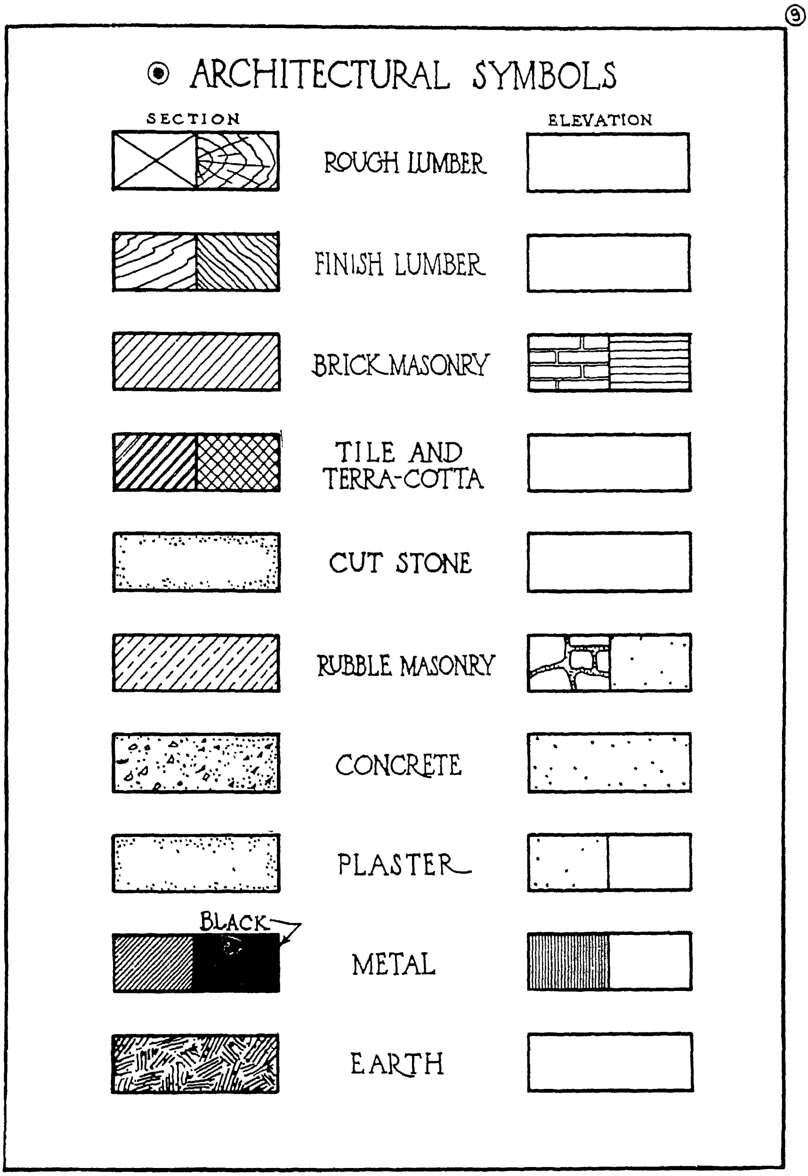
BROKEN STONE	SCREENINGS
SLAG	GRAN. SLAG
GRAVEL	CINDERS
CHATS	SAND
BURNT CLAY	EARTH

SIGN BOARDS AND POSTS

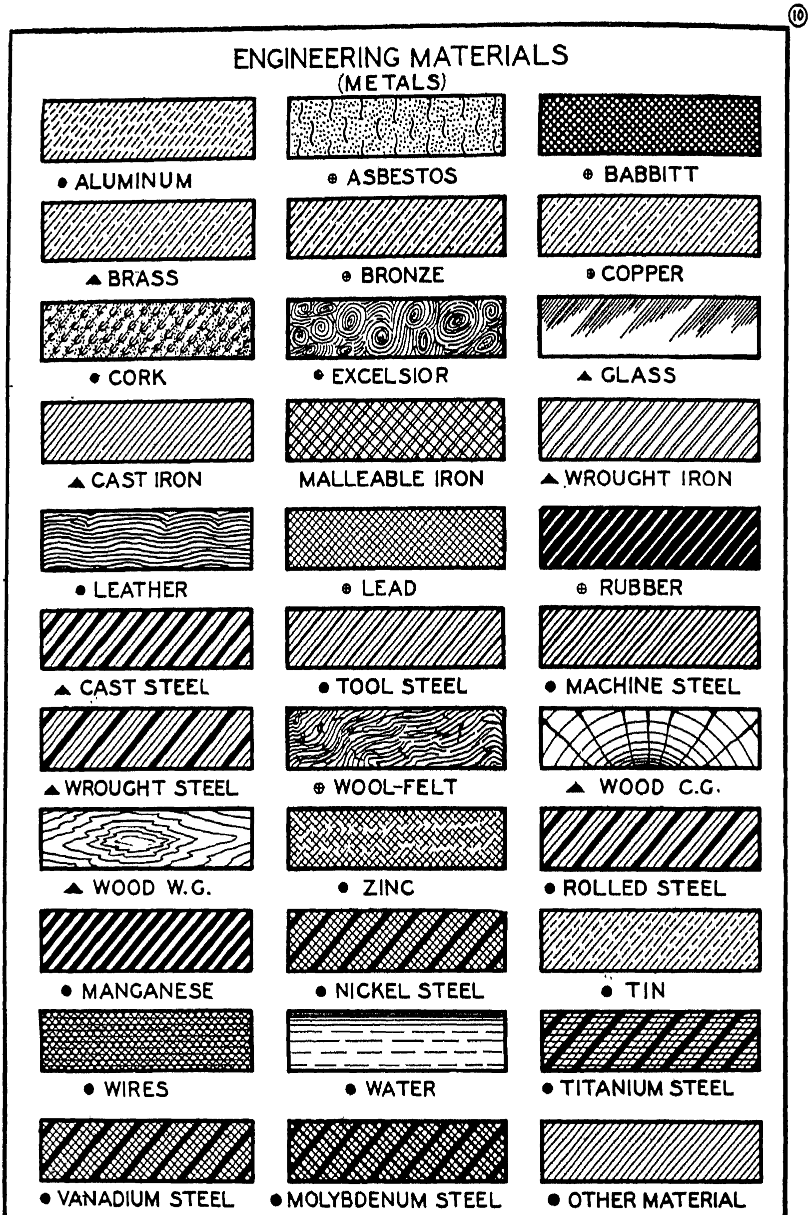
▲ MILE POST	15 16	▲ SECTION POST	Sec. 5 6
▲ YARD LIMITS	Y. L.	▲ FLANGER SIGN	F
▲ WHISTLE POST	W	▲ CROSSING SIGN	
• OTHER SIGNS	*Describe With Letters.*	• OTHER POSTS	*Describe With Letters.*

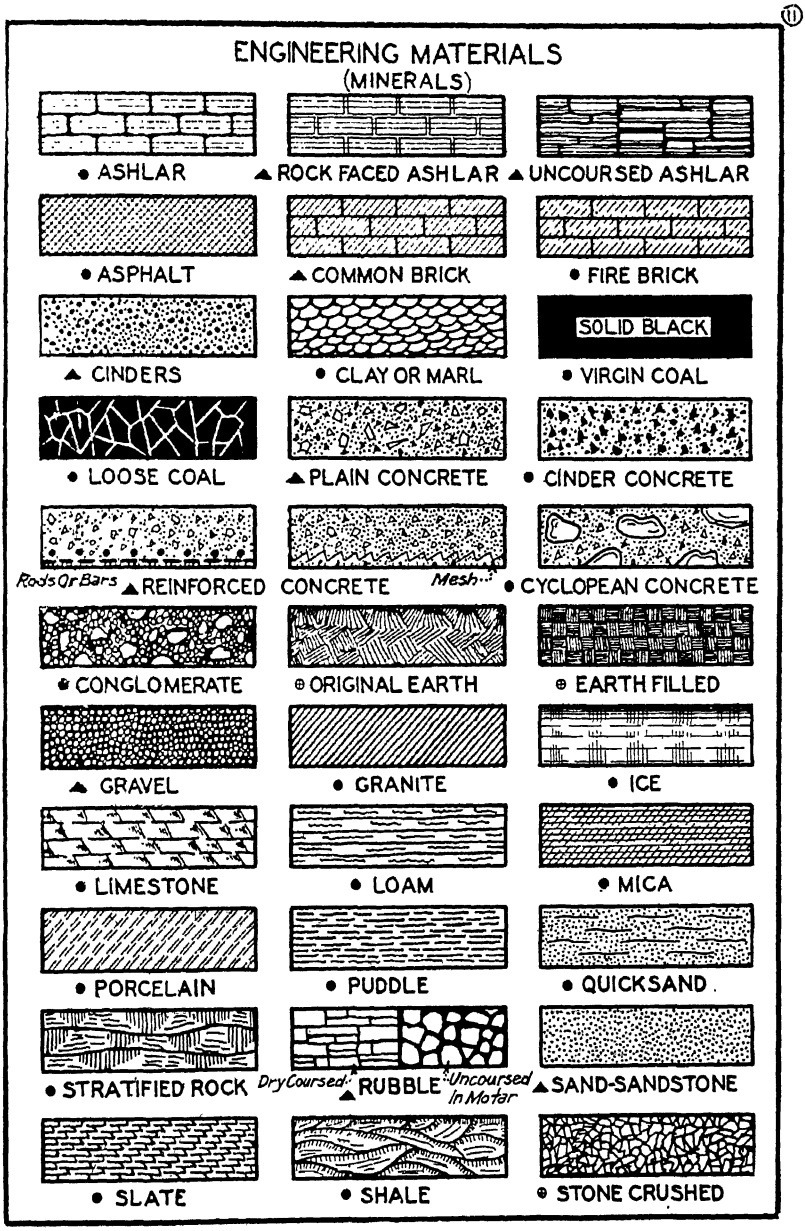
▲ BRIDGE AND TUNNEL WARNING

FOR SYMBOLS OF CROSSING FLASHERS, BELLS AND OTHER SIGNAL APPLIANCES SEE SIGNAL SYMBOLS.



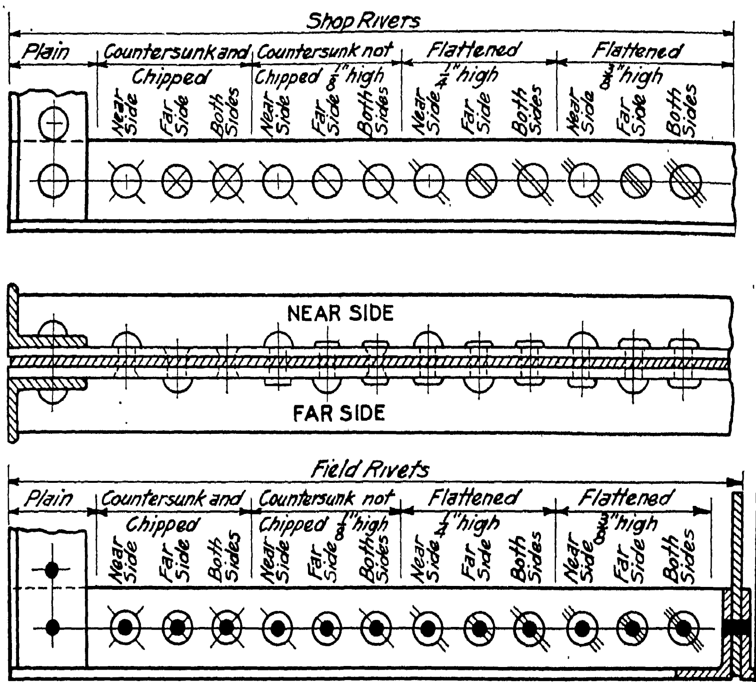
9
ARCHITECTURAL SYMBOLS
SECTION
ELEVATION
ROUGH LUMBER
FINISH LUMBER
BRICK MASONRY
TILE AND TERRA-COTTA
CUT STONE
RUBBLE MASONRY
CONCRETE
PLASTER
BLACK
METAL
EARTH


(10)
ENGINEERING MATERIALS
(METALS)
● ALUMINUM
⊕ ASBESTOS
⊕ BABBITT
▲ BRASS
⊕ BRONZE
⊕ COPPER
● CORK
● EXCELSIOR
▲ GLASS
▲ CAST IRON
MALLEABLE IRON
▲ WROUGHT IRON
● LEATHER
⊕ LEAD
⊕ RUBBER
▲ CAST STEEL
● TOOL STEEL
● MACHINE STEEL
▲ WROUGHT STEEL
⊕ WOOL-FELT
▲ WOOD C.G.
▲ WOOD W.G.
● ZINC
● ROLLED STEEL
● MANGANESE
● NICKEL STEEL
● TIN
● WIRES
● WATER
● TITANIUM STEEL
● VANADIUM STEEL
● MOLYBDENUM STEEL
● OTHER MATERIAL

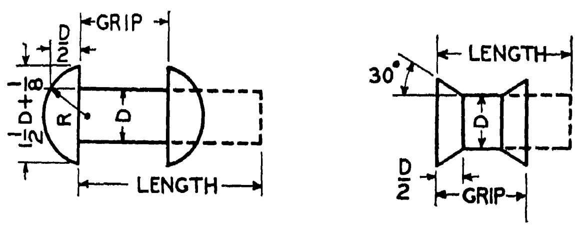

⑪
ENGINEERING MATERIALS
(MINERALS)
• ASHLAR
▲ ROCK FACED ASHLAR
▲ UNCOURSED ASHLAR
• ASPHALT
▲ COMMON BRICK
• FIRE BRICK
SOLID BLACK
▲ CINDERS
• CLAY OR MARL
• VIRGIN COAL
• LOOSE COAL
▲ PLAIN CONCRETE
• CINDER CONCRETE
Rods Or Bars ▲ REINFORCED CONCRETE Mesh
• CYCLOPEAN CONCRETE
• CONGLOMERATE
⊕ ORIGINAL EARTH
⊕ EARTH FILLED
▲ GRAVEL
• GRANITE
• ICE
• LIMESTONE
• LOAM
• MICA
• PORCELAIN
• PUDDLE
• QUICKSAND
• STRATIFIED ROCK
Dry Coursed ▲ RUBBLE Uncoursed In Motar
▲ SAND-SANDSTONE
• SLATE
• SHALE
⊕ STONE CRUSHED

(12)

⊕ A-BRIDGE RIVETS



NOTE:- $\frac{1}{2}''$ AND $\frac{5}{8}''$ RIVETS TO BE FLATTENED $\frac{1}{4}''$. $\frac{3}{4}''$-$\frac{7}{8}''$ AND 1'' RIVETS TO BE FLATTENED $\frac{3}{8}''$.



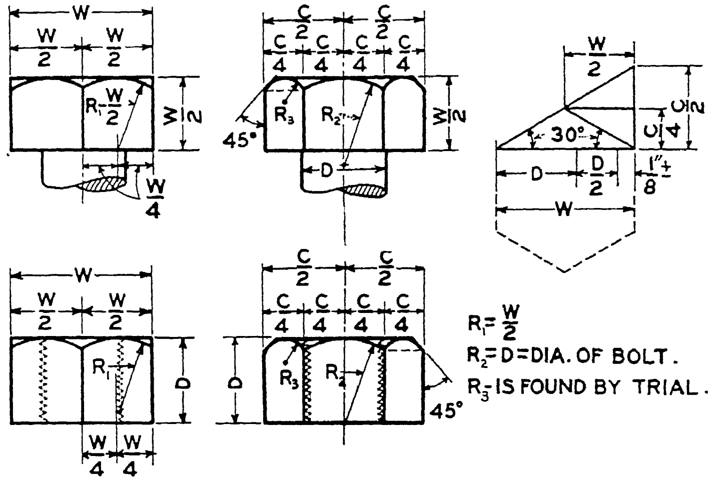
▲ B-STRESSES

+ TENSION

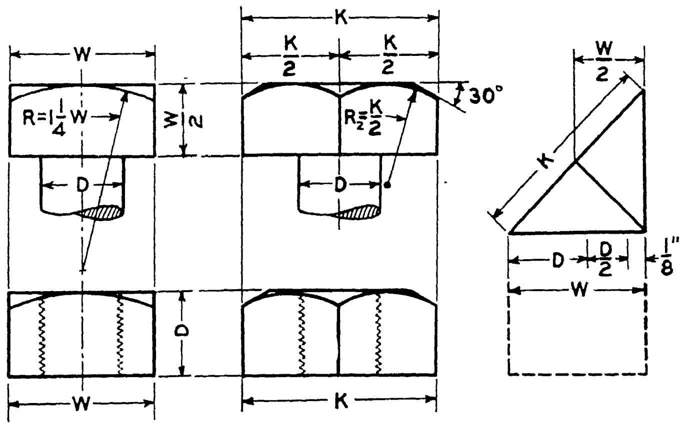
− COMPRESSION

13

BOLTS AND NUTS



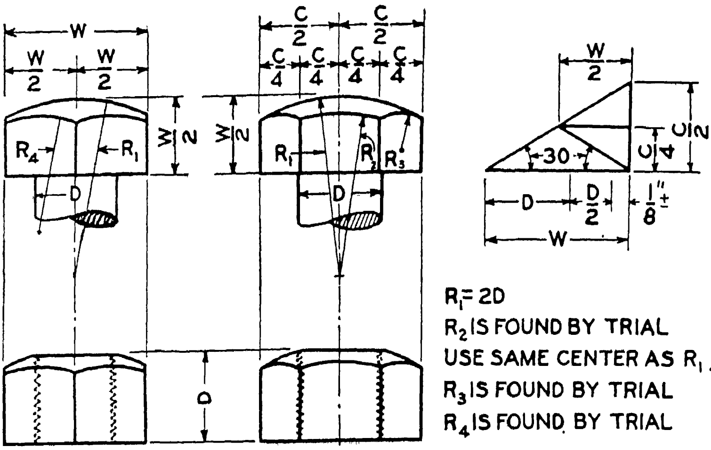
CONSTRUCTION OF U.S STD. HEX HEAD AND NUT



CONSTRUCTION OF U.S STD SQUARE HEAD AND NUT

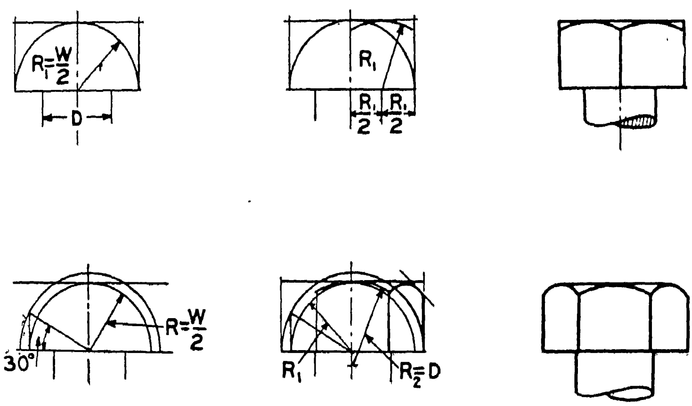
⑭

◉ BOLTS AND NUTS

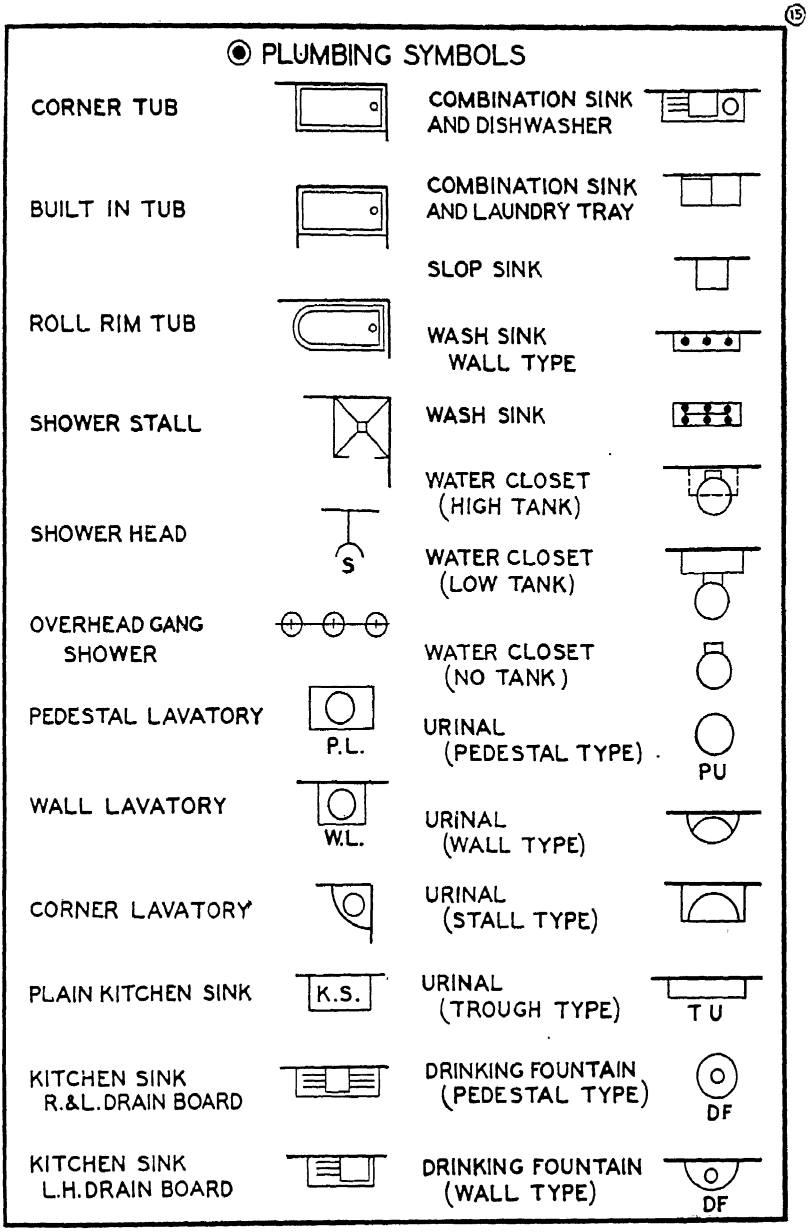


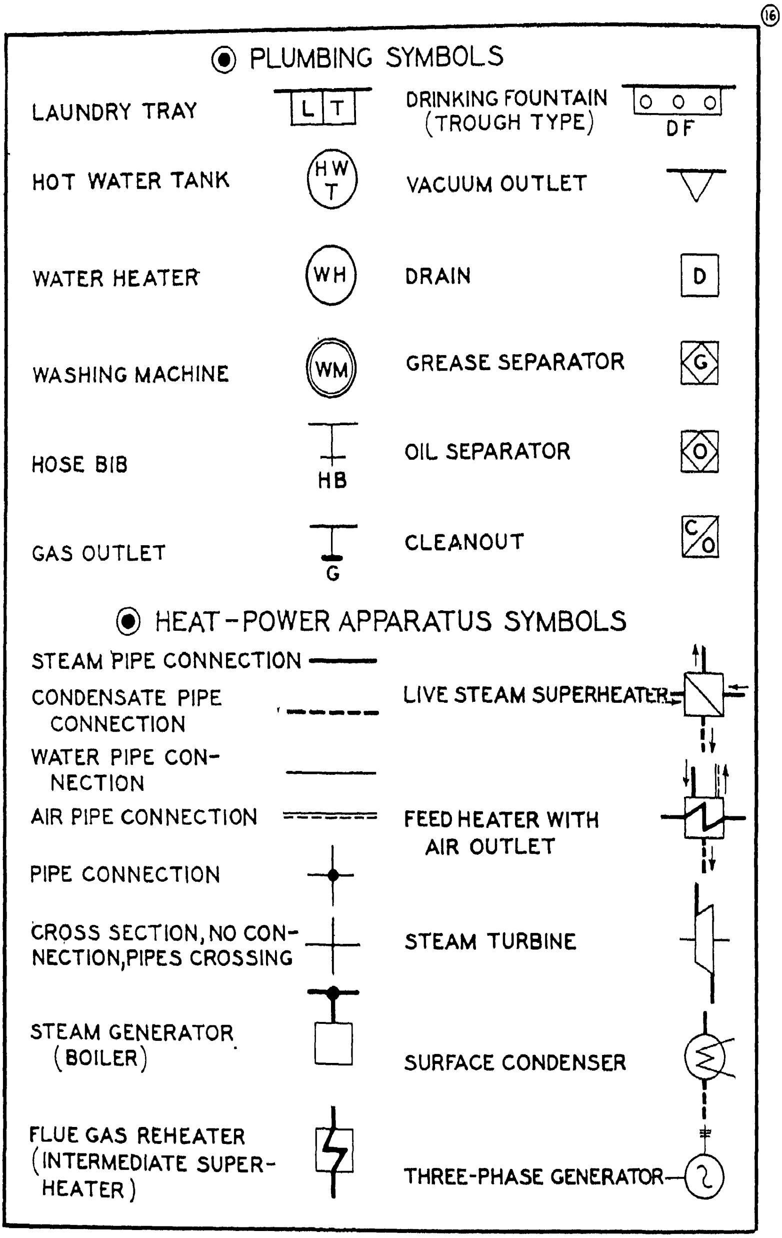
$R_1 = 2D$
R_2 IS FOUND BY TRIAL
USE SAME CENTER AS R_1.
R_3 IS FOUND BY TRIAL
R_4 IS FOUND BY TRIAL

CONSTRUCTION OF ROUNDED HEX HEAD AND NUT.

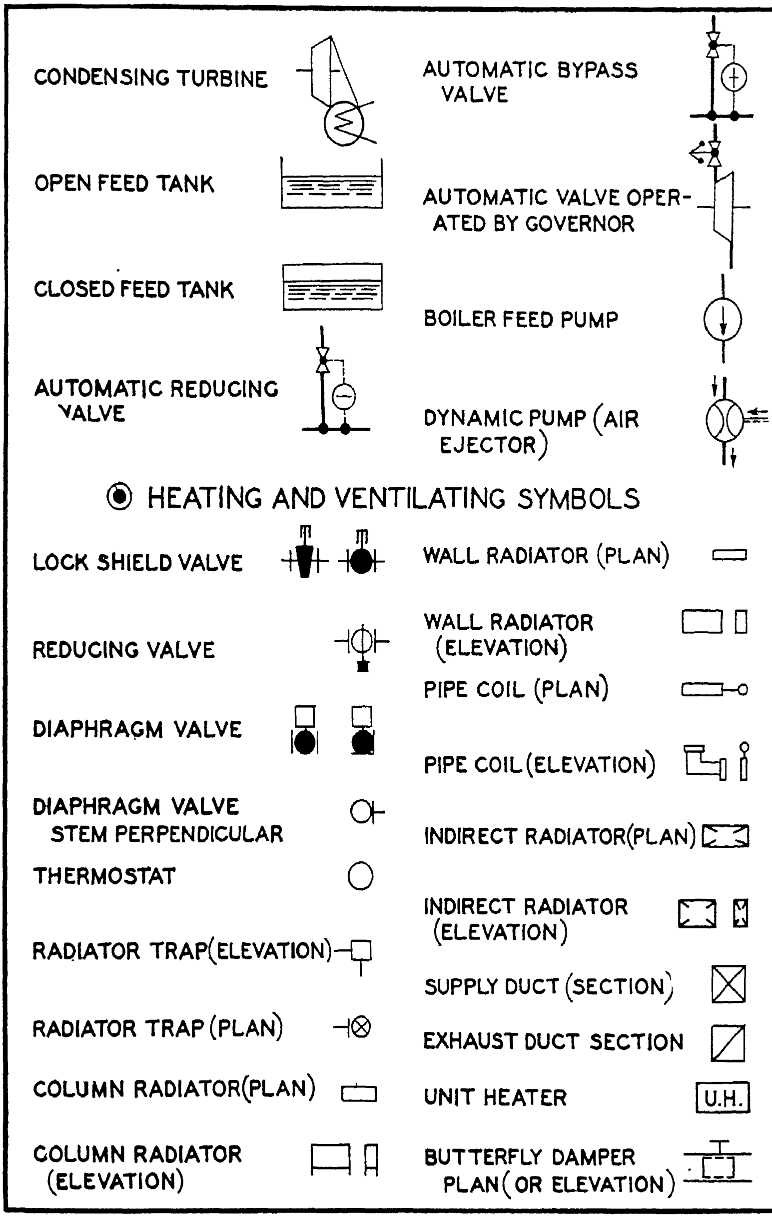


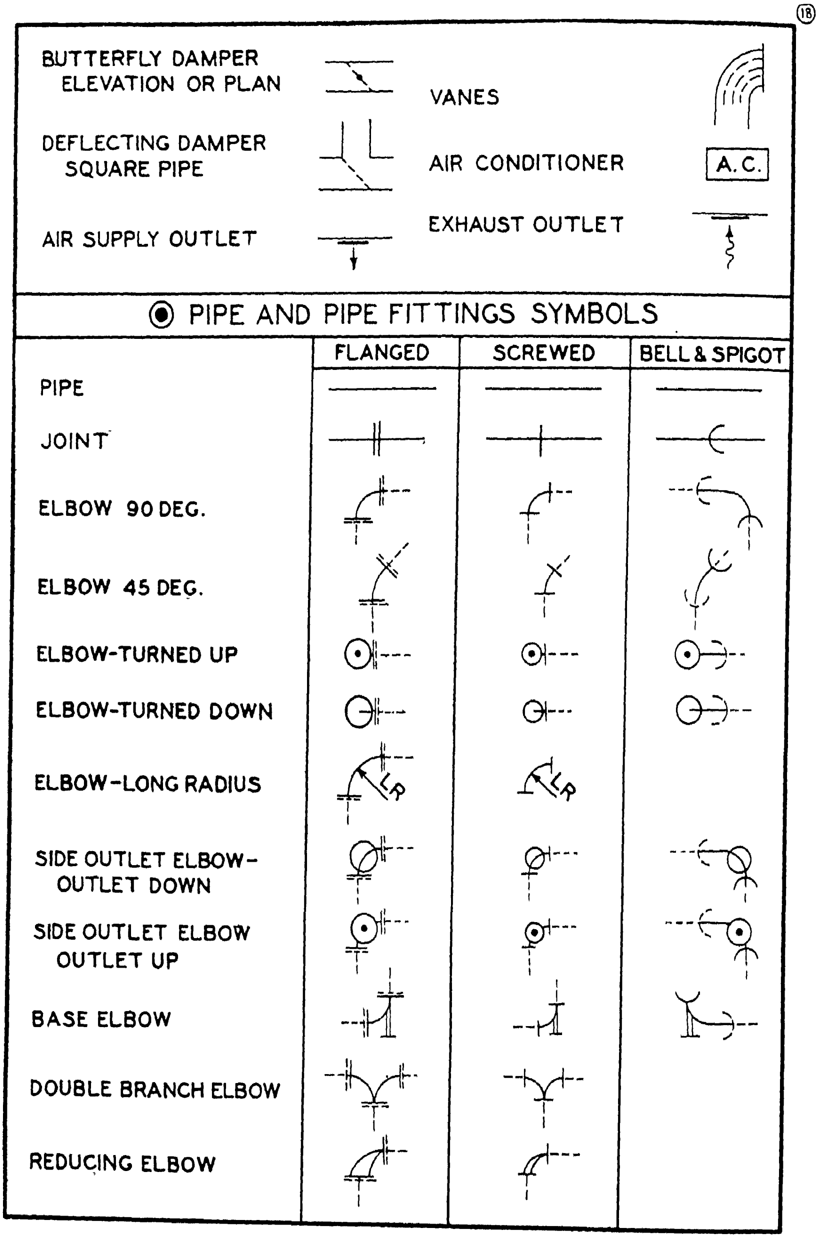
SEMICIRCLE CONSTRUCTION FOR HEX HEAD

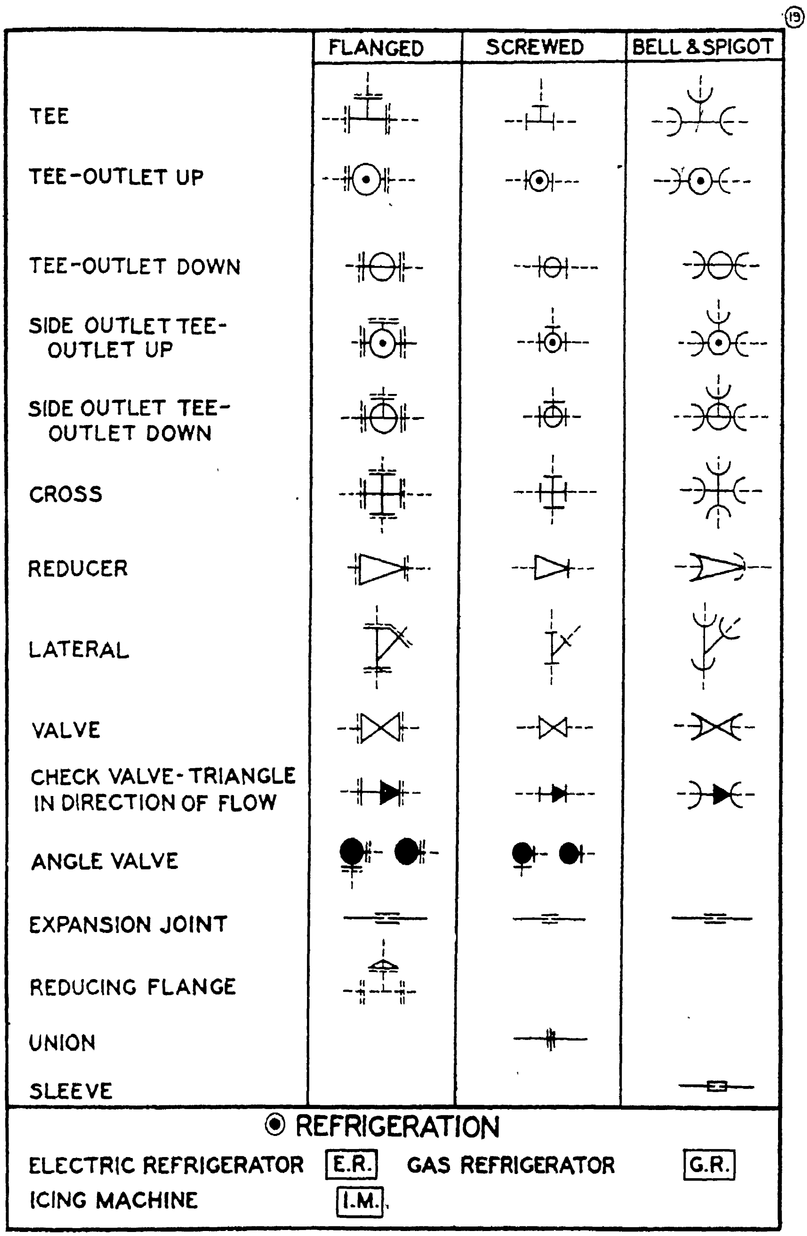

15
PLUMBING SYMBOLS
CORNER TUB
BUILT IN TUB
ROLL RIM TUB
SHOWER STALL
SHOWER HEAD
S
OVERHEAD GANG SHOWER
PEDESTAL LAVATORY
P.L.
WALL LAVATORY
W.L.
CORNER LAVATORY
PLAIN KITCHEN SINK
K.S.
KITCHEN SINK R.&L. DRAIN BOARD
KITCHEN SINK L.H. DRAIN BOARD
COMBINATION SINK AND DISHWASHER
COMBINATION SINK AND LAUNDRY TRAY
SLOP SINK
WASH SINK WALL TYPE
WASH SINK
WATER CLOSET (HIGH TANK)
WATER CLOSET (LOW TANK)
WATER CLOSET (NO TANK)
URINAL (PEDESTAL TYPE)
PU
URINAL (WALL TYPE)
URINAL (STALL TYPE)
URINAL (TROUGH TYPE)
TU
DRINKING FOUNTAIN (PEDESTAL TYPE)
DF
DRINKING FOUNTAIN (WALL TYPE)
DF


16
PLUMBING SYMBOLS
LAUNDRY TRAY
L T
DRINKING FOUNTAIN (TROUGH TYPE)
DF
HOT WATER TANK
HWT
VACUUM OUTLET
WATER HEATER
WH
DRAIN
D
WASHING MACHINE
WM
GREASE SEPARATOR
G
HOSE BIB
HB
OIL SEPARATOR
O
GAS OUTLET
G
CLEANOUT
C O
HEAT-POWER APPARATUS SYMBOLS
STEAM PIPE CONNECTION
CONDENSATE PIPE CONNECTION
WATER PIPE CONNECTION
AIR PIPE CONNECTION
PIPE CONNECTION
CROSS SECTION, NO CONNECTION, PIPES CROSSING
STEAM GENERATOR (BOILER)
FLUE GAS REHEATER (INTERMEDIATE SUPERHEATER)
LIVE STEAM SUPERHEATER
FEED HEATER WITH AIR OUTLET
STEAM TURBINE
SURFACE CONDENSER
THREE-PHASE GENERATOR

17


CONDENSING TURBINE
OPEN FEED TANK
CLOSED FEED TANK
AUTOMATIC REDUCING VALVE
AUTOMATIC BYPASS VALVE
AUTOMATIC VALVE OPERATED BY GOVERNOR
BOILER FEED PUMP
DYNAMIC PUMP (AIR EJECTOR)
HEATING AND VENTILATING SYMBOLS
LOCK SHIELD VALVE
REDUCING VALVE
DIAPHRAGM VALVE
DIAPHRAGM VALVE STEM PERPENDICULAR
THERMOSTAT
RADIATOR TRAP(ELEVATION)
RADIATOR TRAP (PLAN)
COLUMN RADIATOR(PLAN)
COLUMN RADIATOR (ELEVATION)
WALL RADIATOR (PLAN)
WALL RADIATOR (ELEVATION)
PIPE COIL (PLAN)
PIPE COIL(ELEVATION)
INDIRECT RADIATOR(PLAN)
INDIRECT RADIATOR (ELEVATION)
SUPPLY DUCT (SECTION)
EXHAUST DUCT SECTION
UNIT HEATER
U.H.
BUTTERFLY DAMPER PLAN(OR ELEVATION)


18
BUTTERFLY DAMPER ELEVATION OR PLAN
VANES
DEFLECTING DAMPER SQUARE PIPE
AIR CONDITIONER
A.C.
AIR SUPPLY OUTLET
EXHAUST OUTLET
PIPE AND PIPE FITTINGS SYMBOLS
FLANGED
SCREWED
BELL & SPIGOT
PIPE
JOINT
ELBOW 90 DEG.
ELBOW 45 DEG.
ELBOW-TURNED UP
ELBOW-TURNED DOWN
ELBOW-LONG RADIUS
LR
LR
SIDE OUTLET ELBOW-OUTLET DOWN
SIDE OUTLET ELBOW OUTLET UP
BASE ELBOW
DOUBLE BRANCH ELBOW
REDUCING ELBOW


19
FLANGED
SCREWED
BELL & SPIGOT
TEE
TEE-OUTLET UP
TEE-OUTLET DOWN
SIDE OUTLET TEE-OUTLET UP
SIDE OUTLET TEE-OUTLET DOWN
CROSS
REDUCER
LATERAL
VALVE
CHECK VALVE-TRIANGLE IN DIRECTION OF FLOW
ANGLE VALVE
EXPANSION JOINT
REDUCING FLANGE
UNION
SLEEVE
REFRIGERATION
ELECTRIC REFRIGERATOR
E.R.
GAS REFRIGERATOR
G.R.
ICING MACHINE
I.M.

Appendix C

(B-2) JOINT FACILITY RECORDS

(a) Appraisal methods and records for keeping up-to-date
(b) Maintenance and operation reports and records
(c) Effect of depreciation accounting

B. A. Bertenshaw, Chairman, Sub-Committee; Anton Anderson, D. L. Avery, E. V. Braden, E. S. Butler, James Erskine, W. L. Foster, C. C. Haire, J. H. Hande, G. R. Walsh.

Where facilities are used jointly by two or more railroads, the use, maintenance and operation of the facilities in question are made the subject of a formal contract or agreement. It is common practice in such a contract to provide for the using company to pay to the owning company a rental for the use of such joint facilities. This rental is a specified per cent per annum on a rental base which is agreed upon at the time the agreement is made.

The determination of the rental base is in most cases subject to prolonged negotiation, and various records and methods have been used in arriving at this base. The Committee has made a study of the various ways of determining this base and find the following to have been most commonly used:

1. Appraised value agreed to by interested parties.
2. Ledger value or original cost.
3. Estimated original cost.
4. Reproduction cost.
5. I.C.C. Valuation (Tentative or Final).

After the rental base has been determined and specified in the contract it becomes necessary to keep this base current, due to changes in the facilities from time to time. The Committee has accordingly made a study of the various methods used in keeping the rental base up to date, and finds the following methods most common:

1. By adding the net amount of additions and retirements as lodged in the accounting records.
2. By maintaining a detail of the original appraisal, with additions and retirements, and retiring therefrom items that can be identified, or equitably estimated portions thereof, at the amount included in such detail for the facilities retired.
3. In case of retirements, retire from rental base the percentage which the property retired bears to the total.

The studies so far made indicate the special need of some simple method of keeping the rental base up to date due to changes in facilities, and also for some system of forms and/or records to be placed in the hands of those responsible for the maintenance and operation of the joint facilities, in order that they may perform in accordance with the agreement.

This being a new assignment, the studies of the Committee have not progressed to a point where it is possible to recommend methods or forms such as are mentioned above. This report is therefore submitted as one of progress, with the recommendation that the subject be continued for further study.

Appendix D

(C-1) STATISTICAL REQUIREMENTS OF OPERATING, ACCOUNTING AND OTHER DEPARTMENTS WITH RESPECT TO MAINTENANCE OF WAY AND STRUCTURES

W. F. Cummings, Chairman, Sub-Committee; Anton Anderson, D. L. Avery, E. V. Braden, W. L. Foster, W. E. Gardner, C. R. Harte, W. R. Kettenring, J. R. Leguenec, Jr., W. M. Ludolph, W. S. McFetridge, F. X. Soete, A. P. Weymouth.

The work of this Sub-Committee is to study progressively and report as to forms and data called for on chart shown on page 278, Vol. 27 of the Proceedings. A survey of the forms presented to date appear on page 896, Vol. 31 of the Proceedings.

This year the Committee has undertaken to present a form of daily report covering work equipment in service. The term "Work Equipment" is intended to include special purpose rolling equipment regularly assigned to the Maintenance of Way and Structures Department, all special machines and labor-saving devices

There seems to be a lack of such reports on most roads and those that are available differ greatly.

The purpose of the form presented here is to furnish such data as will meet the requirements enumerated in the report of the Committee last year and shown on pages 597 and 598, Vol. 33 of the Proceedings.

Foreman's Daily Report of Work Equipment

This form is roughly divided into five (5) parts:

The first or top part provides space for recording information as to territory and location in which equipment is working and the kind and number of machine.

The second part—columns 2 to 8 inclusive—provides space for reporting the kind and amount of work performed, the time and rate of labor operating the equipment and the kind and quantity of repairs, if any, made and supplies used by the operating crew.

The third part—column 9—provides for recording how the expense connected with the operation of the equipment shall be charged out, that is whether to A.F.E.—straight maintenance—outside parties, etc., subdivided to show character of work.

The fourth part—columns 10 and 11—provides space for recording the amount and cause of delays.

The fifth part provides for recording information as to conditions affecting operation that would be usable in permitting the Supervisors, Division Engineers, or other officers, to determine whether or not the equipment is being efficiently and economically operated.

On the reverse side is a list of machines generally used with a key letter indicating same. The letter indicating the kind of machine should be shown on the face of the form under heading—"Kind of machine".

Likewise instructions for the use of the form are shown on the reverse side.

It is intended that a separate report, covering each piece of equipment in the jurisdiction of a Foreman or Operator, shall be made out for each day whether or not the equipment is in use, except that if several machines of the same type are being used on the same operation, one form shall suffice for the several numbers shown on the face of the report.

It is intended that during off seasons when a large amount of equipment is not being used that some means will be arranged so that for equipment not being used regularly

it will not be considered that it is in the jurisdiction of the Foreman or Operator and it would therefore not be necessary to make a daily report covering.

Action Recommended

It is recommended that this report be accepted as information.

(Size of sheet 8½" X 11") (Front)

NORTH AND SOUTH RAILROAD COMPANY

____________________ DEPT.

FOREMAN'S DAILY REPORT OF WORK EQUIPMENT

KIND OF MACHINE (See instructions on back)		_________ DIV., DISTRICT NO.____ LOCATION____________
MACHINE NO. (1)		WORK, MP____ To MP____ OR STRUCTURE____________

UNITS (2)	NO. OF UNITS OF WORK (3)	LABOR POSITION (4)	HOURS (5)	RATE (6)	REPAIRS OR SUPPLIES KIND (7)	QUANT. (8)	KIND (7)	QUANT. (8)
CU. YD.		FOREMAN			COAL		FUSE PLUGS	
TONS		ASST. FOREMAN			WATER		ROAD OIL	
MILES		TIME KEEPER			FUEL OIL		KEROSENE	
LIN. FT.		SEC. LABOR			GASOLINE		HOSE	
TRK. FT.		EX-GANG LABOR			LUBR. OIL		NOZZLES	
JOINTS		WATER-BOY			ROPE		CHAINS	
PILING, FT.		OPERATOR			CABLE		OXYGEN	
TIES		CRANEMAN			SICKLES		ACETYLENE	
SQUARES		FIREMAN			DISCS		WELD. RODS	
INCHES		WATCHMAN			SAWS		CHEMICAL	
RAILS		BRIDGEMAN			BITS		WASTE	
HOLES		DIVER			DIPPER TEETH		PACKING	
FROGS		CARPENTERS			SPARK PLUGS		WHEELS	
SWITCHES		MASONS			BATTERIES			
		PLUMBERS						
		PIPE FITTERS			DELAYS			
		SHEET METAL WORKERS			HOURS (10)	MINS.	CAUSE (11)	
CHARGE TO (9)		ELECTRICIANS						
		REPAIRMEN						
		HELPERS						
		PAINTERS						
		LOCO. ENGINEER						
		" FIREMAN						
		CONDUCTOR						
		BRAKEMAN						
		PILOT						

REMARKS

State if machine is IDLE; or if IN TRANSIT, between what points.
Describe if item in column (2), Units, does not indicate clearly what is done.
Describe any condition affecting best operation of machine, need of shop repairs, etc.
(12).

____
FOREMAN OR OPERATOR

DATE ____________ 19____

(Back)

INSTRUCTIONS

To report Kind of Machine in space (1) on face of report, use letters as shown opposite name of machine in list below. (Example: XP for Weed Burner)

If more than one machine of the same kind is used on the same job on the same day, show all Machine No.'s in space (1) on one report and total labor and other items in proper columns.

If item in column (2) does not indicate clearly what is done describe more fully under Remarks, column (12).

Show number of units of work performed in column (3). Under Labor, columns (5) and (6), report hours and rates of all employees working on or with the machine opposite the proper Position. Show quantities of supplies used in column (8). In column (9) show whether the work performed should be charged to Maintenance (M/W), Individuals and Companies (I&C) or Additions and Betterments (A&B). If to I&C, show name; if to A&B show A.F.E. number. Subdivide to show character of work.

Show in columns (10) and (11) amount and cause of delays.

Make a separate report for each kind of machine in charge of Foreman or Operator whether idle, in transit or in use, and send to Supervisor at close of each day. If idle or in transit show under Remarks, column (12).

ADZING MACHINE	A		SHOVEL, CAR (STEAM-GASOLINE-DIESEL-ELEC. CROSS OUT, EXCEPT KIND USED)	XB
AIR COMPRESSOR,- MISCELL OPERATIONS	B		SHOVEL, CRAWLER (STEAM-GASOLINE-DIESEL-ELEC. CROSS OUT, EXCEPT KIND USED)	XC
BALLAST CLEANER	C		SPIKE DRIVER, POWER	XD
CONCRETE MIXER	D		SPIKE PULLER, POWER	XE
CRANE (STEAM-GASOLINE-DIESEL-ELECTRIC CROSS OUT, EXCEPT KIND USED)	E		TIE BORER, POWER	XF
CRANE-LOCO. (STEAM-GASOLINE-DIESEL-ELEC. CROSS OUT, EXCEPT KIND USED)	F		TIE TAMPER (AIR - ELECTRIC CROSS OUT, EXCEPT KIND USED)	XG
DERRICK CAR	G		TRACK BALLASTER	XJ
DISCING MACHINE	H		TRACK MOWER	XK
DITCHER	J		TRACK OILER	XL
DITCHER-SPREADER	K		TRACK RAISER	XM
HOISTING ENGINE	L		TRACK SHIFTER	XN
NUT RUNNER, POWER	M		TRACTOR (GASOLINE - DIESEL CROSS OUT, EXCEPT KIND USED)	XO
PAINT SPRAY MACHINE	N		WEED BURNER	XP
PILE DRIVER (DROP HAMMER-STEAM HAMMER CROSS OUT, EXCEPT KIND USED)	O		WEED DESTROYER, CHEMICAL	XR
RAIL DRILL, POWER	P		WELDING OUTFIT (OXY-ACETYLENE-ELECTRIC CROSS OUT, EXCEPT KIND USED)	XS
RAIL GRINDER, POWER	R		(Write in any other machine)	XT
RAIL LAYER (PORTABLE - CAR CROSS OUT, EXCEPT KIND USED)	S			
RAIL LOADER	T			
RAIL SAW, POWER	XA			

Appendix E

(C-2) SYSTEM OF REPORTS AND RECORDS REQUIRED TO BUDGET AND CONTROL MAINTENANCE OF WAY EXPENSES

E. Y. Allen, Chairman, Sub-Committee; Anton Anderson, D. L. Avery, R. R. L. Bullard, W. F. Cummings, W. E. Gardner, J. R. Leguenec, Jr., W. S. McFetridge, A. T. Powell, A. P. Weymouth.

This subject was first assigned in 1931. A progress report was made last year which was published in the 1932 Proceedings, Vol. 33, page 588.

This year the Committee presents an outline of the principal reports required. This outline is shown as Exhibit 1. When detail forms are prepared for the various reports, it may be found necessary to make more than one form to cover the matter required for one report as outlined.

This is submitted as a progress report.

Exhibit 1

OUTLINE OF A SYSTEM OF RECORDS AND REPORTS REQUIRED TO BUDGET AND CONTROL MAINTENANCE OF WAY EXPENSES

Requests for Appropriations		*Authorized Appropriations*		*Comparison between Appropriations and Expenses*		
Prepared by Supervisors and General Foremen						
Annual Request for Appropriation for Sub-Division	Monthly Request for Appropriation for Sub-Division			Daily and/or Weekly Comparison between Appropriation and Expenses for Sub-division	Monthly Comparison between Appropriation and Expenses for Sub-Division	
Prepared by Division Engineers and Others in Direct Charge of Maintenance of Way Work						
Annual Request for Appropriation for Division or Department	Monthly Request for Appropriation for Division or Department	Tentative Annual Appropriation for Sub-Division	Monthly Apporopriation for Sub-Division	Weekly Comparison between Appropriation and Expenses for Division or Department	Monthly Comparison between Appropriation and Expenses for Division or Department	Annual Comparison between Appropriation and Expenses for Division or Department
Prepared by Chief Engineer of Maintenance of Way						
Annual Request for Appropriation for System	Monthly Request for Appropriation for System	Tentative Annual Appropriation for each Division and Department	Monthly Appropriation for each Division and Department	Weekly Comparison between Appropriation and Expenses for System	Monthly Comparison between Appropriation and Expenses for System	Annual Comparison between Appropriation and Expenses for System
Prepared by Officer in Charge of Budget						
		Tentative Annual Appropriation for System	Monthly Appropriation for System			

Appendix F

(C-3) FORMS USED BY RAILWAY WATER SERVICE DEPARTMENTS

D. C. Teal, Chairman, Sub-Committee; James Erskine, W. E. Gardner, F. C. Kane, J. R. Leguenec, Jr., D. W. Smith, F. X. Soete, James Stephenson, Louis Wolf.

The subject is a continuation of the assignment made three years ago. Study of forms now in common use by railway water service departments has resulted in a general classification of reports and records as follows:

(1) Monthly and yearly record of cost of producing and treating water.
(2) Pumpers and treating plant operators reports.
(3) Water station record.
(4) Geological record of deep wells.

Progress report in Vol. 32, 1931, page 523, of the Proceedings, presents a form covering the first general class of monthly and yearly record of cost of producing and treating water. This form is recommended as the permanent "Cost of Water Production" record to be compiled and kept in the headquarters of the official having charge of water supply for the division or system.

Progress report in Vol. 33, 1932, page 598, presents a form belonging to the second general class. This form "Monthly Report of Water Station Operation" is recommended to provide for the basic information of water production and consumption and is to furnish part of the underlying data with which to compile the permanent "Cost of Water Production" record as well as other information necessary for the close check of water station performance.

This year the Committee, to complete the study of the second general classification, has prepared a form for the reporting of treating plant operation, which is presented herewith as Exhibit 3.

The Committee has also prepared a form covering the third general classification for the recording of water station facilities which is presented herewith as Exhibit 4.

EXHIBIT 3—FORM 1301-A

This form is designed for the daily recording and periodic reporting of treating plant operation and is to supply information necessary for control and check of treating plant performance, to keep close check of chemical supplies and to furnish underlying data with which to compile the permanent "Cost of Water Production" record.

The title "Quarter Monthly Report of Treating Plant Operation" is believed to cover the subject adequately. Quarter monthly or weekly reporting of treating plant operation is very necessary for proper supervision. Quarter monthly is recommended over weekly reporting, as being in general better adapted for handling in connection with the monthly "Cost of Water Production" record.

The recommended standard letter size of 8½"x11" will give ample room for posting of figures and data. Instructions for routine of handling are noted on the form.

Column headings are more or less self explanatory. Columns 1 to 12 provide necessary and detail information for check of plant operation and chemical control of plant as well as data for the permanent cost record. Columns 13 to 22 furnish a complete record of chemical supplies used and on hand. This information is very necessary when ordering additional supplies and is also required for the permanent cost record.

This form supplements Form 1301—Revised, and is believed to be adapted to present-day water service uses.

Form 1301-A is presented to the Association this year as information and will be recommended for adoption in the Manual at a later date.

EXHIBIT No 3
FORM 1301-A
RECOMMENDED SIZE - $8\frac{1}{2}$" x 11"

THE NORTH AND SOUTH RAILROAD
QUARTER MONTHLY REPORT OF WATER TREATING PLANT OPERATION

__________ STATION __________ DIVISION, PERIOD ENDING __________ 19___

MONTH OF ____ 19__				GALLONS OF WATER		CHEMICAL FORMULA LBS. PER VAT INCH			LBS OF CHEMICALS USED				APPEARANCE OF WATER	
CHECK DATES COVERED				PUMPED	TREATED	LIME	SODA ASH.	COAG	LIME	SODA ASH	COAG	COAG	RAW	TREATED
(1)				(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	8	16	24											
2	9	17	25											
3	10	18	26											
4	11	19	27											
5	12	20	28											
6	13	21	29											
7	14	22	30											
	15	23	31											
TOTALS FOR PERIOD														

RECORD OF CHEMICAL SUPPLIES

CHEMICAL SUPPLY ITEM	UNIT	ON HAND FIRST OF PERIOD	RECEIVED DURING PERIOD	TOTAL TO ACCOUNT FOR	ON HAND END OF PERIOD	AMOUNT USED	UNIT PRICE	COST FOR PERIOD	HANDLING CHARGES
(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
LIME	LBS								
SODA ASH	LBS.								
COAG. ________									
COAG. ________									
							TOTAL FOR PERIOD		

REMARKS:- ____________________

SIGNED - ____________________
ATTENDANT IN CHARGE

SIGNED :- ____________________
WATER SUPPLY SUPERVISOR

INSTRUCTIONS -
THIS REPORT TO BE PREPARED IN QUADRUPLICATE BY ATTENDANT IN CHARGE OF PLANT.
ORIGINAL AND ONE COPY TO BE MAILED TO SUPERVISOR
SUPERVISOR TO FORWARD APPROVED ORIGINAL TO SUPT WATER SUPPLY
ONE COPY TO BE SENT DIRECT FROM TREATING PLANT TO CHIEF CHEMIST.
COLUMNS 2 TO 12 INCLUSIVE TO BE POSTED EACH DAY BY ATTENDANT
COLUMNS 14 TO 19 " " " " AT END OF PERIOD BY ATTENDANT.
COST INFORMATION TO BE OBTAINED FROM MATERIAL ACCOUNTING DEPT.

Division:-____________

Date:-____________

The North and South Railroad
Record of Water Station Facilities

Exhibit No 4
Form - 1303 - Revised.

Location			Water Supply																Water Tanks							Water Columns	
			Average Daily Consumption	Source	Wells					Purchased Water				Intake Sump		Capacity of Supply	Reliability of Supply	Quality of Water									
								Water Level		Meter		Contract															
Station	M.P.	Date Installed		Lake, Stream or Reservoir	Kind	Size	Depth	Static	Working	Kind	Size	Term	Rate	Kind	Size				Available Capacity	Size	Kind	Type Delivery	Kind Frame	Kind Frost Box	Kind Foundation	Size	Kind and Make
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)

Pumping Equipment																									
Pumps			Engines		Boilers		Combined Pumps			Electric Motors						Automatic Equipment	Deep Well Pumps								
																	Pump Head		Working Barrel		Turbine Pump		Size of Drop Line	Depth Setting	
Kind and Make	Size	GPM	H.P	Kind and Make	Kind and Make	Size	H P	Kind and Make	GPM	Kind and Make	HP	RPM	Volt	Phase	Cycle	Kind & Make	Kind & Make	Size	Kind & Make	Size	Kind & Make	Size			GPM
(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)

Pumping Equipment													Pipe Lines														
Air Lifts					Compressors		Hydraulic Rams			Wind Mills			Suction			Discharge			Gravity			Water Column Supply			Other Lines		
		Size																									
Type Nozzle	Depth Setting	Air	Disch	GPM	Kind and Make	Capacity	Kind	Size	GPM	Kind	Height Tower	Diam Wheel	Size & Kind	Length	Lift	Size & Kind	Length	Head	Size & Kind	Length	Head	Size & Kind	Length	Average Head	Size & Kind	Length	Use
(55)	(56)	(57)	(58)	(59)	(60)	(61)	(62)	(63)	(64)	(65)	(66)	(67)	(68)	(69)	(70)	(71)	(72)	(73)	(74)	(75)	(76)	(77)	(78)	(79)	(80)	(81)	(82)

Buildings								Fuel Storage						Treating Plant Equipment												
Pump Houses			Pump Pits		Chemical Houses			Coal			Oil Tanks				Mixing Vats	Chemical Pumps		Chemical Control		Electric Motors						Automatic
Type	Size	Foundation	Kind	Size	Type	Size	Foundation	Type	Size	Capacity	Kind	Size	Capacity	Type of Plant	Kind & Size	Kind & Make	Size	Kind & Make	Size	Kind & Make	HP	RPM	Volt	Phase	Cycle	Equipment Kind & Make
(83)	(84)	(85)	(86)	(87)	(88)	(89)	(90)	(91)	(92)	(93)	(94)	(95)	(96)	(97)	(98)	(99)	(100)	(101)	(102)	(103)	(104)	(105)	(106)	(107)	(108)	(109)

EXHIBIT 4—FORM 1303—REVISED

This form is intended for a permanent record of water station facilities and as such to be kept in the headquarters of the operating and maintenance officials in charge of division and system.

The title "Record of Water Station Facilities" is believed to cover the subject intended. Column headings call for only essential information, as details regarding each facility would require a form that would be too large and unwieldy to be satisfactory. Column headings cover necessary information for intelligent answering of any general question that might come up concerning facilities at water station in question.

The form should be adapted to conform to requirements of company using. It can be set up for blue print reproduction on one or more individual sheets; kept on printed form in loose leaf book with headings printed on both sides; or the information called for can be kept in a card index file.

This form supersedes Form 1303 now in the Manual and is believed to be adapted to cover present-day water service organizations.

Form 1303—Revised is presented to the Association this year as information and will be recommended for adoption in the Manual at a later date.

Appendix G

(E-1) METHODS AND FORMS FOR GATHERING THE DATA FOR KEEPING UP TO DATE THE VALUATION AND OTHER RECORDS OF THE PROPERTY OF RAILWAYS WITH RESPECT TO

(a) Changes made necessary by government regulations

(b) Simplicity and practicability of use

W. W. James, Chairman, Sub-Committee; E. Y. Allen, B. A. Bertenshaw, E. V. Braden, V. H. Doyle, D. E. Field, W. E. Gardner, A. T. Hopkins, W. R. Kettenring, C. A. Knowles, E. W. Metcalf, A. T. Powell, H. L. Restall, James Stephenson, H. J. Stroebel, Louis Wolf, W. H. Woodbury.

The purpose of the Committee this year has been to review the forms previously submitted by Committee XI and, after carefully considering the entire situation in a broad manner, determined which forms are obsolete and of little use; which forms should be held in abeyance; and which should be retained, with or without revision. The Committee has had in mind that a proposed new uniform system of accounts embodying depreciation accounting is under consideration, consequently, it has been thought best to hold certain matters in abeyance for the present.

Following is a list of forms included in the Proceedings and/or Manual.

Reference No.	*Subject*	*Proceedings Reference Volume*	*Year*	*Page*	*Exhibit No.*	*1929 Manual Page*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Authority for Expenditures	29	1928	881	9	719
2	Detailed Estimate	29	1928	882	10	
		33	1932	603	4	721
3	Register of Authorities for Expenditures	33	1932	603	3	723
3-a	Report of Quantities in Completed Work	29	1928	871	5	
4	Roadway Completion Report	32	1931	512	8	724
5	Equipment Completion Report	31	1930	872	8	
		31	1930	874	10	725

Reference No.	Subject	Proceedings Reference Volume	Year	Page	Exhibit No.	1929 Manual Page
6	Record of Property Changes	29	1928	874	21	
		29	1928	909	22	
		29	1928	910	23	
		30	1929	602	A	
		30	1929	604	C	
		31	1930	865	1	
		31	1930	866	2	
		31	1930	867	3	
7 & 8	Record of Equipment Changes	29	1928	874	17	
		30	1929	606	E	
		31	1930	875	11	
		29	1928	906	18	
		29	1928	907	10	
		29	1928	908	20	
9	Equipment Unit List	31	1930	876	12	
10	Shop Machinery and Tools	29	1928	905	16	
		32	1931	516	11	
11	Roadway Machine Record	29	1928	904	15	
		32	1931	515	10	
12 13	Record of Side Tracks List of Side Tracks	29	1928	900	11	
		31	1930	871	7	716
		33	1932	601	1	
14	Building Record	29	1928	901	12	
		29	1928	902	13	
15	Construction Report Timber Trestles	29	1928	911	24	
16	Construction Report, Wood Boxes & Pipe Culverts	29	1928	912	25	
17	Construction Report, Concrete Trestles Arches and Boxes	29	1928	913	26	
18	Construction Report, Steel Bridges	29	1928	914	27	
19	Report of Rail Change	29	1928	915	28	
20	Report of Ballast Change	29	1928	916	29	
21	Record of Rail in Track	29	1928	917	30	
22	Record of Heat Number	29	1928	918	31	
23	Collection Sheet for B.V. Form 589	30	1929	607	F	
24	Reconciliation with Form 588	31	1930	868	4	
25	Adjustment Unit Changes	31	1930	870	6	
26 to 32 incl.	Methods and Forms for Bringing Land Valuations to Date	32	1931	507 to 511	1–7	
33	Price Trends	32	1931	517	12	
34	Definition of Terms	29	1928	852		
		32	1931	503		701
		Bul. No. 337, July 1931, p. 79				

The Committee makes the following recommendations as to these forms:

1. Authority for Expenditures

It is recommended that Form 1113 Rev., Proceedings, Vol. 29, 1928, page 881, be included in the Manual with the text as shown in the 1929 Manual on pages 720 and 721.

It is recommended that Form 1113, as shown in the 1929 Manual, page 719, be withdrawn.

2. Detailed Estimate

It is recommended that Form Exhibit 4, Proceedings, Vol. 33, 1932, page 603, be included in the Manual as Form 1114 Rev., with the text as shown in the 1929 Manual on page 722.

It is recommended that Form No. 1114, shown in the 1929 Manual, page 721, be withdrawn.

3. Register of Authorities for Expenditures

It is recommended that Form Exhibit 3, Proceedings, Vol. 33, page 603, be included in the Manual as Form 1115 Rev., the text to accompany same to read as follows:

(c) Register of Authorities for Expenditure Form 1115 Rev.
Specifications for Form 1115 Rev.
Form as here shown. Size 11x17 inches. Printed on white medium ledger paper; all lines and printing black. Horizontal lines five to the inch.
Instructions for Use of Form 1115 Rev.
As each project is authorized, the number, date, location, description and estimated cost should be entered on this form in order of the numbers assigned. As the completion reports are submitted the remaining information called for on the form should be entered at once. This form is designed to be kept in a loose-leaf binder. One book should be kept for each owning company.

It is recommended that Form 1115, as shown in the 1929 Manual, page 723 and the text pertaining to same, shown on page 722, be withdrawn.

4. Roadway Completion Report

The Committee approves the form shown in Proceedings, Vol. 32, page 512, Exhibit 8 (in lieu of Form 1117 shown in the 1929 Manual, page 724) but recommends that the publication of this form in the Manual be held in abeyance until after the proposed new uniform system of accounts is issued.

5. Equipment Completion Report

It is recommended that Form 1118, as shown in the 1929 Manual, page 725, remain without change.

6. Record of Property Changes
7 and 8. Record of Equipment Changes
9. Equipment Unit List

The record of property changes follows the completion report. (1) The first step in compiling the record of property changes should be the recording of all property changes in a condensed form by years. (2) It should consist of the collection of items for use in the preparation of B.V. Form 588 R and its sub-schedules. (3) It should consist in keeping a running record, or a perpetuation, of quantities for all years.

In view of the possibility of Depreciation Accounting prescribed under I.C.C. Docket 15100 (which may require a more detailed record of property changes than that required by Valuation Order No. 3 and its Supplements), the Committee feels that it is unwise at this time to recommend any additions to or changes in the text or forms now in the 1929 edition of the Manual.

The Committee recommends that these three subjects be held in abeyance until the atmosphere has cleared in respect to I.C.C. Docket 15100, and in respect to possible legislation affecting valuation procedure.

10. Shop Machinery and Tools

It is recommended that Form Exhibit 11, Proceedings, Vol. 32, 1931, page 516, be included in the Manual with the following text:

Specifications for Form Exhibit 11.
Form as here shown. Size 8½x11 inches. Printed on white medium ledger paper; all lines and printing black; horizontal lines five to the inch.
Instructions for Use of Form Exhibit 11.

There will be only one machine recorded on a sheet. The sheets will be kept in machine number order or by location and title of machines, as desired.

11. Roadway Machine Record

It is recommended that Form Exhibit 10, Proceedings, Vol. 32, 1931, page 515, be included in the Manual with the following text:

Specifications for Form Exhibit 10.

Form as here shown. Size 8½x11 inches. Printed on white medium ledger paper; all lines and printing black; horizontal lines five to the inch.

Instructions for Use of Form Exhibit 10.

This form is designed to record roadway machines according to kind, such as motor cars, concrete mixers, etc.

12. Record of Side Tracks

13. List of Side Tracks

It is recommended that Form Exhibit 7, Proceedings, Vol. 31, 1930, page 871, be included in the Manual with the following text:

Specifications for Form Exhibit 7.

Form as here shown. Size 11x17 inches. Printed on white medium ledger paper; all lines and printing black; horizontal lines five to the inch.

Instructions for Use of Form Exhibit 7.

This form is an individual side track record designed to keep an up-to-date record of side tracks. Provision has been made for showing the principal characteristics of the track with valuation inventory quantities and subsequent changes thereto for items in the various accounts. In order to conform with the information required and save space, the vertical ruling above the double line immediately over line 1 and to the right of Column 3 should be left off the form and inserted as the form is made up; for example: an A.F.E. may include only units added, in which case a double vertical line will be extended to the top of the form as illustrated by Column 4; another A.F.E. may have units added and units retired that had been included in the basic valuation, in which case the vertical double line ruling would be as illustrated in Columns 5 and 6; where an A.F.E. contains all cases, that is, units added and units retired both from Engineering Report and from property installed subsequent to valuation date, the ruling would be as illustrated by Columns 7, 8 and 9. Again the retired units are subdivided into those installed before and after valuation date. If desired, a sketch of the track may be kept on the reverse side of the form on which may be shown by survey stations or otherwise the exact location of changes made in the track.

14. Building Record

It is recommended that Form Exhibit 12 and 14, Proceedings, Vol. 29, 1928, pages 901 and 903, be included in the Manual (eliminating from Exhibit 14 the clause "and 13"), with the following text:

Specifications for Form Exhibit 12 and 14.

Form as here shown. Size 8½x11 inches. Printed on white medium ledger paper; all lines and printing black.

Instructions for Use of Form Exhibit 12 and 14.

These forms are designed for the purpose of keeping a detailed record of all buildings. It is intended that all structures of this character should be numbered and changes to each building recorded by "Authorities for Expenditures." Exhibit 14 is the reverse side of Exhibit 12. This form may be used as a card index.

23. Collection Sheet for B.V. Form 589

Form Exhibit "F", Proceedings, Vol. 30, 1929, page 607, was designed for use in compiling B.V. Form 589. Supplement No. 6 to Valuation Order No. 3, Second Revised Issue, effective Jan. 1, 1930, provides that upon application to and with the approval of

the Director of the Bureau of Valuation, carriers may be relieved from preparing and filing B.V. Form No. 589 for any period or periods for which the complete reports are filed upon forms like B.V. Form 588.

24. Reconciliation with Form 588

It is recommended that Forms Exhibit 4 and 5, Proceedings, Vol. 31, 1930, page 868, be included in the Manual with the following text:

Specifications for Forms Exhibit 4 and 5.

Forms as here shown. Size 11x17 inches. Printed on white medium ledger paper; all lines and printing black; horizontal lines five to the inch.

Instructions for Use of Forms Exhibit 4 and 5.

Forms Exhibit 4 and 5 are for use in reconciling the amounts reported on B.V. Form 588 with the amounts charged to Investment in Road and Equipment. Exhibit 4 has the binding margin on the right while Exhibit 5 has binding margin on left. The headings under "year ended December 31st," will, of course, need to be modified to agree with the valuation date. Exhibit 5 will show at a glance for each A.F.E. the total charged on ledger and the corresponding amount shown on B.V. Form 588, with the difference recorded in Column 3. Columns 4 to 15, inclusive, collect the information in proper form for reporting and recording in accordance with Valuation Order No. 25. In Column 16 will be listed the items corresponding to the amounts shown in Columns 6, 9, 12 and 15, "Other Reasons."

26 to 32 inclusive. Methods and Forms for Bringing Land Valuations to Date

It is recommended that carriers make use of forms printed and used by the I.C.C., Bureau of Valuation, Land Section. These forms can be secured upon application to the Interstate Commerce Commission.

List of Such Forms

B.V. Form No. 501-RR	—Land Field Notes
B.V. Form No. 502	—Local Opinions of Values of Similar Lands
B.V. Form No. 504	—Sales Record of Similar Lands
B.V. Form No. 504-X	—Supplemental Sales Sheet
B.V. Form No. 505	—Latest Assessments of Similar Lands
B.V. Form No. 506-R	—Additional Form for Establishment of Assessment Ratio
B.V. Form No. 507-R	—Supplemental Sheet
	Form Letter for Requesting Information

All of these forms are 8½x11 inches, punched for loose-leaf use and are substantially the same as those shown heretofore in the Proceedings. The use of these forms has the advantage of allowing the Bureau and the Carrier to receive duplicate copies of each other's data, and corrections may be made in such a manner that the underlying data can be readily checked by either party.

Appendix H

(E-2) METHODS USED IN RECAPTURE PROCEEDINGS

Chas. Silliman, Chairman, Sub-Committee; A. Anderson, H. T. Bradley, E. S. Butler, C. A. Knowles, J. R. Leguenec, Jr., W. S. McFetridge, E. W. Metcalf, James Stephenson, W. H. Woodbury.

In the report of the Committee for 1931, attention was called to the move in Congress to bring about a change in the Transportation Act relative to the recapture of so-called excess earnings. In February, 1932, the House Committee on Interstate and

Foreign Commerce, Samuel Rayburn, Chairman, held an extended hearing on Bills H.R. 7116 and 7117. At this hearing Commissioner Eastman, for the Interstate Commerce Commission, recommended the repeal of Section 15a of the Transportation Act. Mr. Thom, representing the Association of Railway Executives, supported this and went further, recommending the repeal of Section 19a as well. Commissioner Lewis, of the Interstate Commerce Commission, earnestly advocated the continuance of 19a and the organization the Commission has for its handling. Other witnesses, including representatives of the Security Owners' Association, the National Association of Public Utilities Commissioners, the Labor Organizations, etc., recommended the repeal of the recapture law. In fact, no evidence to the contrary appeared.

On April 28, Chairman Rayburn introduced in the House of Representatives a bill, H.R. 11677, consisting of two parts, one with reference to consolidations and the status of holding companies, and the other, like H.R. 7117, covering the repeal of the recapture law. The report of the Committee accompanying the Bill contained two minority reports, one objecting to the consolidation and holding company section; the other minority report dissenting from the recommendation for repeal of the recapture law and suggesting instead that it be modified to the extent that a longer period than one year be considered in computing so-called excess income, in order that the carriers' revenue in fat years might offset the lean years, etc.

Early in May an effort was made to have the Rules Committee advance this Bill for hearing on account of the approach of the close of the session, but this request was denied.

A bill similar to the so-called Howell Bill, described in our report of last year, was submitted to the Senate some time ago, and referred to a sub-committee, but no action has been taken thereon.

In his testimony before the House Committee, Commissioner Eastman pointed out that up to and including the year 1930, the carriers' recapture liability amounted to approximately $361,000,000, of which $10,679,000 had been paid in.

Richmond, Fredericksburg & Potomac RR., F.D. 3898—The situation regarding this interesting case, as set out in our last report, is not materially changed at this time. The application for injunction against the Comptroller General having been decided adversely by the District of Columbia Supreme Court, an appeal was taken to the District Court of Appeals. This was heard on October 7th.

In the meantime the United States brought suit against the carrier for the recapture amounts, to which suit the carrier has filed a motion to dismiss. After the motion was filed the Interstate Commerce Commission intervened as a party plaintiff. The answer to the motion is due to be filed not later than November 19th.

St. Louis & O'Fallon Ry. Recapture Proceeding, F.D. 3908.—On July 28, 1932, a further proposed report, by Examiner P. A. Conway, was released. The progress of this famous case is as follows:

Feb. 27, 1926—Examiner Kelly Report
Feb. 15, 1927—Decision of Commission
May 20, 1929—Decision of Supreme Court
Jan. 23, 1930—Oral Arguments
Feb. 10, 1930—Proceedings ordered reopened
May 5, 1930—Hearing begun, Examiner Folsom
June 10, 1930—Hearing concluded
July 28, 1932—Report of Examiner Conway

As a result, apparently, of attaching greater weight now to the factor of cost of reproduction than was attached in the original report, and after some six years' consid-

eration, a reduction of some 12½ per cent is made in the recapture amounts. This reduction is approximately $28,814. Substantially all of the contentions of the carrier at the last hearing are overruled, and no new principles developed that have not been brought out in the R.F.&P. Case. There are no substantial differences in the amounts for the several elements underlying the determination of value.

Lehigh & New England Railroad, F.D. 3803.—A proposed report by Examiner M. H. Brinkley was released in July, 1932. This case is of particular interest on account of the vigorous attack made by the carrier on the Bureau method of determining depreciation. The proposed report, however, overrules the contentions of the carrier in this matter.

Norfolk & Western Railway Recapture Hearing, F.D. 3865, began in February, 1932, and continued to July, the reproduction claims of the carrier having been presented. This hearing will be resumed the latter part of October.

Pere Marquette Recapture Hearing, F.D. 3886, began in July, 1932, and the carrier's case, or testimony, was concluded October 12th.

The Bessemer & Lake Erie Railroad, F.D. 3633, and the Union Railroad Company, F.D. 3966, were jointly begun on September 14th and concluded October 8th.

Tentative recapture reports have been issued upon a number of short line carriers. dates set for the hearings on the carrier protests, and in many cases the hearings completed.

On September 27th announcement was made that, at the instigation of a number of leading banks and principal insurance companies of the country, a committee composed of Hon. Calvin Coolidge, Chairman; Hon. Alfred E. Smith, Bernard M. Baruch, Clark Howell, and Alexander Legge, had been formed to make a careful survey of the transportation industry and point out remedies needed to assist in the improvement of the general business conditions throughout the country, as well as investigate and recommend legislation or other means necessary to correct the present deplorable position of the railroads.

Appendix I

(F-2) DEVELOPMENTS UNDER I.C.C. ORDER NO. 15100—DEPRECIATION CHARGES OF STEAM RAILWAY COMPANIES

J. H. Hande, Chairman, Sub-Committee; E. Y. Allen, B. A. Bertenshaw, A. M. Blanchard, E. V. Braden, H. T. Bradley, R. R. L. Bullard, V. H. Doyle, James Erskine, D. E. Field, C. R. Harte, W. W. James, W. R. Kettenring, P. R. Leete, Henry Lehn, A. T. Powell, H. L. Restall, F. C. Sharood, H. J. Stroebel, G. R. Walsh, Louis Wolf.

This Committee has submitted four previous reports under the assignment "Methods and Forms for Handling the I.C.C. Requirements under Order No. 15100—Depreciation Charges of Steam Railway Companies," which were published in the Proceedings of the Association as follows:

Volume	30, 1929,	page 612,	Bulletin	313
"	31, 1930,	" 877,	"	322
"	32, 1931,	" 519,	"	333
"	33, 1932,	" 613,	"	344

As previously reported, the Commission released early in September, 1931, its final report and Order in Docket No. 15100, decided July 28, 1931. Under date of March 14, 1932, the effective date requirements of this Order were officially postponed for one year, the primary account composite depreciation rates to be submitted by September 1, 1933, and depreciation accounting inaugurated January 1, 1934.

Successive tentative drafts of the proposed new "Uniform System of Accounts," embodying depreciation accounting, have been issued from time to time, but only for use in revision conferences between accredited representatives of the Commission and of the carriers. The last of these tentative drafts was issued in March, 1932, in a limited number of copies for conference use only. Until the new classifications are issued in final form and are made effective by Order of the Commission, it is inexpedient for this Committee to submit further analyses of depreciation requirements to this Association.

The Committee wishes to state, however, that it has made substantial progress in preparing a complete report on recommended procedure and forms under the requirements of the March, 1932, tentative draft, which can be brought into accord with the final text of the classifications very shortly after their promulgation. Discussions will continue with regard to recommended procedure and forms to the end that the report may be as complete and representative as possible, and be ready for publication if and when the new classifications are formally made effective by the Commission.

Appendix J

(F-3) METHODS FOR AVOIDING DUPLICATION OF EFFORT AND FOR SIMPLIFYING AND CO-ORDINATING WORK UNDER THE REQUIREMENTS OF THE INTERSTATE COMMERCE COMMISSION

F. C. Sharood, Chairman, Sub-Committee; H. T. Bradley, V. H. Doyle, C. C. Haire, F. C. Kane, C. A. Knowles, H. L. Ripley, Chas. Silliman, D. W. Smith, H. J. Stroebel, W. M. Ludolph.

Progress reports upon this subject were presented at the 1931 and 1932 conventions (1931 Proceedings, page 520; 1932 Proceedings, page 618).

Shortly after the 1932 convention, the Interstate Commerce Commission prepared a tentative draft of a new uniform system of accounts for steam railroads which has not been given general circulation.

The Commission, in the draft referred to, has attempted to coordinate its procedure with respect to property investment accounting with the valuation and depreciation matter. However, the proposed system of accounts is only tentative and may be so changed before made final that any benefits contained therein will be lost.

The Committee feels that the procedure in connection with reports to the Bureau of Finance, in the important function of the Commission in the matter of jurisdiction and control of the issuance of securities, should be so modified that data can be compiled from the same basic records as the reports to the Bureau of Valuation are made without the expense in restating and recasting now necessary. Also that annual reports to the Bureau of Statistics can be revised so that the sections of that report which deal with physical property can be made from records kept for other purposes without recasting.

The Committee has reached the conclusion that it is practicable to design a single system of records and reports for all regulatory purposes of the Commission, as well as for carrier use—provided the problem is worked out by the use of intelligent engineering and accounting judgment.

There has been and still is considerable confusion in the dealings of the carriers with the Commission on this subject. The existing conditions will obtain until the carriers coordinate their activities in presenting their views to the Commission.

This Committee has reported many times to this Association that it is a bystander in its relationship to this subject and until such time as it is recognized as a carrier agency working for a common good in an attempt to furnish practical solutions for problems that are essentially within its field of activity, its efforts are probably wasted, but the Committee recommends that the subject be continued on the docket of Committee XI in order that the necessity for united action be kept before the membership of the Association.

Appendix K

(F-4) RECOMMENDED PRACTICE TO BE FOLLOWED IN PREPARING DATA FOR RATE AND OTHER CASES WITH RESPECT TO VALUATIONS, ALLOCATION OF OPERATING AND MAINTENANCE COSTS TO VARIOUS ZONES AND ALLOCATION OF COSTS TO SPECIFIC SERVICES RENDERED

F. C. Sharood, Chairman, Sub-Committee; R. R. L. Bullard, W. F. Cummings, F. C. Kane, Henry Lehn, H. L. Restall, F. X. Soete, James Stephenson, Louis Wolf, W. H. Woodbury.

An oral report on this subject was made at the 1932 convention.

Since this subject was placed on the docket of Committee XI, a very radical change in accounting procedure has been proposed by the Interstate Commerce Commission in the form of a tentative draft of a revised uniform system of accounts for steam railroads, and changes in that section of the Interstate Commerce Act which deals with valuation have been the subject of discussion in Congress.

Therefore your Committee believes that any effort on its part to make recommendations within the scope of this subject at this time would be a useless expenditure of time on its part and money in printing on the part of the Association.

The Committee requests permission to continue this subject on its docket with the understanding that a definite report will be rendered at some later date when the present confusion and uncertainty has been cleared away and the requirements of the Commission as to accounting, depreciation and valuation have been more definitely fixed.

REPORT OF COMMITTEE XXIII—SHOPS AND LOCOMOTIVE TERMINALS

L. P. KIMBALL, *Chairman;*
C. M. ANGEL,
W. H. BARTON,
C. E. BEVERIDGE,
R. A. BLACK,
H. G. DALTON,
A. G. DORLAND,
E. A. DOUGHERTY,
BENJAMIN ELKIND,
C. E. HARRIS,
A. T. HAWK,
L. C. HINSCH,
A. S. KENT,
E. E. KIMBALL,
L. H. LAFFOLEY,
H. C. LORENZ,
J. S. MCBRIDE,
W. S. MCFETRIDGE,
F. E. MORROW,
B. M. MURDOCK,
J. M. METCALF, *Vice-Chairman;*
E. S. PENNEBAKER,
V. B. W. POULSEN,
W. A. RADSPINNER,
E. H. ROTH,
JOHN SCHOFIELD,
L. K. SILLCOX,
H. W. WILLIAMS,
M. J. T. ZEEMAN,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(3) Firing-Up Stations for Locomotives (Appendix A).
(4) Turntables (Appendix B).
(5) Application of Unit Heaters to Shops and Locomotive Terminals (Appendix C).

Progress is also reported on the following subjects:

(1) Revision of Manual.
(2) Welding Equipment Installations as Applied to Shops and Locomotive Terminals.
(6) Wheel Removing Equipment for Engine Houses.
(7) Car Wheel Shops.

Action Recommended

1. That the reports in Appendices A and C be accepted as information.
2. That the conclusions of report in Appendix B be accepted for inclusion in the Manual as a substitution for the matter now appearing under the sub-headings "Turntable" and "Turntable Pit" under the subject heading "Engine House Design" on page 1471 of the 1929 edition.

Respectfully submitted,
THE COMMITTEE ON SHOPS AND LOCOMOTIVE TERMINALS,
L. P. KIMBALL, *Chairman.*

Appendix A

(3) FIRING-UP STATIONS FOR LOCOMOTIVES

L. H. Laffoley, Chairman, Sub-Committee; A. G. Dorland, A. S. Kent, H. C. Lorenz, F. E. Morrow, E. S. Pennebaker, J. Schofield, M. J. T. Zeeman.

Definition

Firing-up Stations are used to ignite the locomotive fires outside the engine house at such terminals where direct steaming is employed, excepting, of course, where there are oil burning locomotives.

In the majority of engine houses where direct steaming is used the locomotives leave the house under their own steam, but without fire and proceed to the Firing-up Station, where, by the use of a vacuum or pressure oil torch system or other means, the fire is lighted.

Location

Firing-up Stations are located on the outbound tracks between the turntable and the coaling station, the distance from the former being about 250 to 400 feet. A typical location is indicated in Fig. 1.

Bulletin 350, October, 1932.

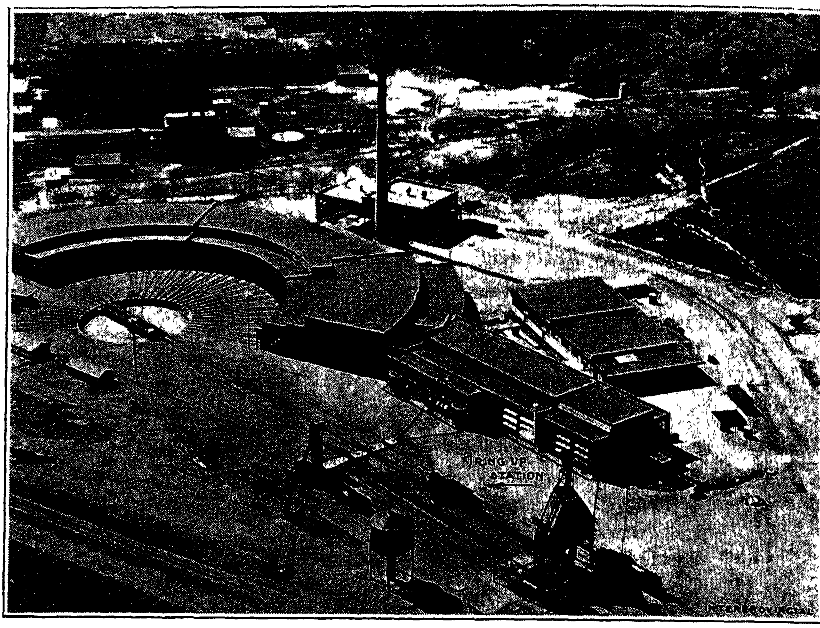


FIG. 1.—Typical Location of Firing-Up Station.

Types of Installation

The installations now in use on various roads may be classified under two general headings, according to the means of housing the firing-up equipment.

(a) Below grade, i.e., housed in a concrete pit, which, where climatic conditions warrant, should be steam heated.

(b) Above grade, i.e., preferably housed in a metal or other fireproof structure situated alongside the outbound engine track.

The firing-up equipment consists of an oil tank provided with the necessary hose and torch or nozzle, the latter being of either vacuum or pressure type.

Installation should include proper protective devices to safeguard oil storage tank from back fire or excessive pressure.

In case (a) where the equipment is housed in a pit, see Fig. 2, the tank is fixed and for that reason requires the locomotive to be spotted within the range of the hose length available.

On the other hand, the pit, being below grade, does not interfere with track clearances as does the house in type (b).

In type (b) with the house above grade, see Fig. 3, the tank and torch equipment can be mounted on wheels, thus providing a more flexible unit.

In both cases compressed air is required and, if at all possible, an oil supply line should be run to the pit or house for replenishing the oil tank supply.

At some points the locomotive fires are ignited by means of oil soaked wood shavings, but this practice is not to be recommended as it causes unnecessary smoke, the avoidance of which is one of the objects of direct steaming.

FIG. 2.—Firing-Up Station with Equipment Housed Below Grade.

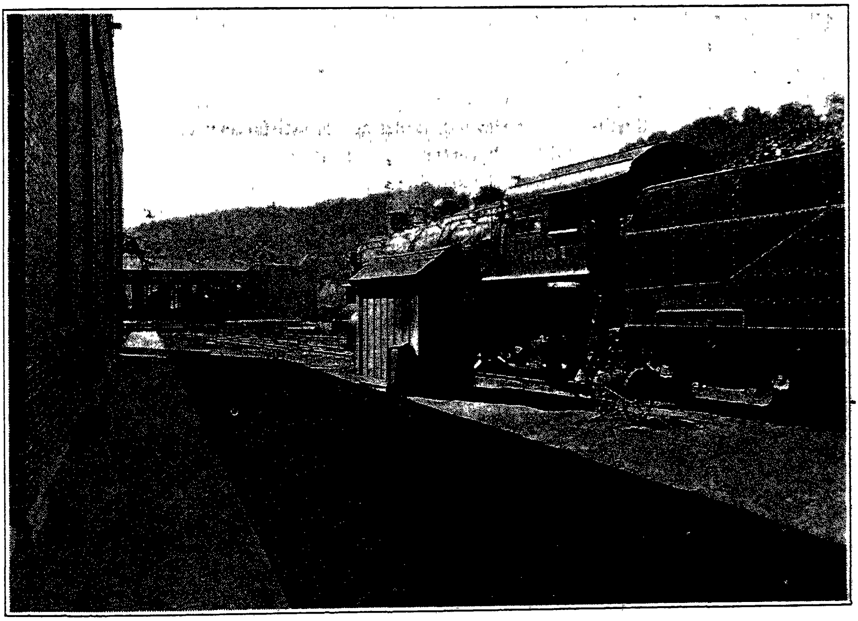


FIG. 3.—Firing-Up Station with Equipment Housed Above Grade.

Appendix B

(4) TURNTABLES

J. M. Metcalf, Chairman, Sub-Committee; C. E. Beveridge, R. A. Black, A. G. Dorland, Benjamin Elkind, H. C. Lorenz, W. S. McFetridge, B. M. Murdock, E. H. Roth.

The technical study of design and specifications for turntables lies within the province of Committee XV—Iron and Steel Structures, and has been well covered by that Committee. Its conclusions appear in the 1929 Manual, pages 1234 to 1239, as recommended "Specifications for Steel Railway Turntables". These are generally recognized as standard practice and are largely used in design and purchase of turntables. This Committee has made no attempt to review them, and feels that when developments may make revisions desirable, they should be made by Committee XV.

As assigned to the Committee on Shops and Locomotive Terminals the subject has been interpreted as applying rather to the functions of turntables, their place in locomotive terminal design, and the essential general features of construction and maintenance.

Turntables are in general use at locomotive terminals for turning power and for providing convenient movement between service tracks and engine houses. The whole design of the circular engine house is based upon the turntable at its center, which makes it possible for locomotives to enter and leave any stall with minimum movement, headed in either direction. At small outlying terminals caring for few locomotives there are advantages in simplicity of operation and maintenance in favor of the wye for turning locomotives. For electric locomotives, designed for operation in either direction, and hence not requiring to be turned at terminals, a rectangular engine house without turntable serves satisfactorily, especially where the number of locomotives handled is not so great as to involve too much complexity in track layout, but for the steam locomotive terminal, where any considerable number of locomotives are cared for, the circular house with stalls radiating from a central turntable, has been found necessary.

The modern turntable is commonly a girder supported at both ends and center, and pivoted in the center so as to be turned readily. Where drainage conditions permit the deeper pit required, the deck type of girder is generally preferred and is less likely to be damaged in case of derailment, but through tables are in satisfactory use at many places, where a shallow pit is desirable. A center bearing designed to facilitate the turning movement, and end support on trucks moving on a circular rail are essential features. The roller type center bearing with heavy conical rollers has been replaced in many recent installations by a bronze flat disc center which is found to stand up better under heavy service, requiring less care and less expense for maintenance. The circle rail, for supporting the end trucks, is commonly a rail of heavy section, curved to the proper radius, and may be set on ties supported on a concrete base, or on special plates or castings set in concrete.

A standard timber bridge deck floored with plank is most commonly used to support the track rails. Length and thickness of ties required depends on spacing of the turntable girders. Special steel beams often are used at the table ends, instead of wood ties, to provide the additional strength required to withstand the impact resulting from movement of locomotives entering the table.

Cleanliness and proper drainage of pit are essential to satisfactory maintenance, and a concrete floor over the entire pit, with adequate sewer is desirable, though macadam or other paving may give fairly successful results.

In modern installations, a concrete rim wall supporting the radial tracks commonly extends around the full circle of the table. A timber wall, sometimes extending only under the portions of the circle where required for the approach tracks, may be used

for outlying installations serving only a few radial tracks, but is less satisfactory for the long deep tables required for modern heavy power. Good practice calls for an opening in the rim wall at one point in the circle, large enough to accommodate one or more workmen inspecting or adjusting the end trucks and tractors.

Coping timbers or steel beams may support the radial track rails on the rim wall. These should be anchored to the concrete wall and the rails held in place both longitudinally and laterally by suitable fastenings. If required, additional anchorage should be provided to prevent the possibility of radial rails creeping to or from the pit. It is desirable that the angles between radial tracks be great enough to make frogs unnecessary. Spacing such that rails of adjacent tracks may be blocked and bolted together helps in holding the rails in proper position.

The use of rail locks to assure that the table rails line with the radial track before a locomotive moves on to or off the table was formerly thought essential but such locks are now commonly omitted or not used.

Until recent years turntables were all designed to support the locomotives balanced on the center and turning with both ends free. Greater length and weight of locomotives made this increasingly difficult and the balanced type of table has given way, in most modern installations, to one in which both ends also are supported. These may be of articulated or twin-span type or of continuous girder type. In either, the girder becomes two spans, each supported at both ends, instead of a single span balanced and supported only in the center. By the use of the three-point type a reduction is effected in the weight of girder necessary to support a balanced locomotive and correspondingly in the depth of pit. There may also be some saving in the length of table required, which in the balanced type must provide a perfect balance under the different conditions resulting from loaded and empty tenders, as well as in the size and design of center. The three-point table, however, requires much greater tractive force, and consequently heavier and more expensive power. It also requires a heavier design of circle rail and circle rail support.

Considerable vertical play is necessary at the ends of a balanced table to provide for the deflection of the table under load. This involves tipping the end down when a locomotive enters and leaves with a pound on the ends and straining of the center. The end supported three-point type should be maintained with table rails at all times practically at the same level as the radial tracks and under these conditions much of the expense of maintaining the track, the table, the trucks and the center is reduced. At the same time, elimination of the necessity for balancing the locomotive on the table speeds up operation and materially increases the capacity of a busy table.

In some cases it may be possible to effect a substantial increase in the life of an old table, designed for balanced operation, and over-stressed under modern power, by converting it to the three-point bearing type. This involves application of heavy end trucks and additional tractive power.

Except for outlying terminals, where only a few light locomotives are turned, the old practice of turning by man-power is obsolete, replaced by mechanical traction. For the older balanced type, tractors, operated by electricity, or in some cases by air and running on the circle rail, may be applied to one or both ends of the table. Electric motors, geared direct to the trucks, at both ends of the table usually supply the power for the modern three-point tables.

As with all machinery, the satisfactory operation of a turntable is dependent upon constant care and frequent thorough inspection. Lubrication of all moving parts at proper intervals is essential. The table should be raised and center carefully inspected at least once each year. All parts of table, machinery and pit should be kept clean,

and the steel should be kept painted. Pit sewer must be kept open and operating properly to insure a dry pit at all times. The maintenance of line and surface of radial tracks must be watched.

Conclusions

1. Use of a three-point turntable is preferable where long locomotives are to be handled. If balanced type table is used, it should be long enough to balance the locomotive when tender is empty.

2. A deck turntable is usually more economical, but in the balanced type a through table may be desirable where use of a deck structure would greatly increase the cost or make satisfactory drainage difficult.

3. Where modern heavy locomotives are to be turned mechanical power for operating turntables should be provided. Where current is available, electricity is the most reliable means of operating a turntable. The power wires should be led to the table underground and so arranged as to minimize danger of interruption of supply in case of fire in the engine house or other emergency. Where electric power is not available, a compressed air motor may be used.

4. The deck of the turntable should be wide enough to provide a walk on each side, and should be protected with handrails.

5. The turntable pit should be paved and adequately drained.

6. The circle wall should preferably be of masonry, with proper supports and fastenings for rails on the coping. A timber or steel coping is preferable to a rigid masonry coping.

7. The circle rail should preferably be supported on concrete base with load properly distributed by ties, plates, or castings.

8. Easy access to the parts of a turntable for the oiling of bearings, painting and inspection should be provided in the design of the pit, unless ample provision is made in the turntable itself.

9. Thorough lubrication, systematic cleaning of both table and pit, and careful inspection at regular intervals are essential to satisfactory operation of a turntable. The table should be raised and center thoroughly inspected at least once a year.

10. Radial tracks should be kept in good line and surface. Radial track and turntable rails should be maintained with proper spacing between their ends and at proper relative elevation.

Recommendation

It is recommended that Conclusions 1 to 10, inclusive, above, be substituted for the matter now appearing under the sub-heading "Turntable" and "Turntable Pit", under the subject heading "Engine House Design" on page 1471 of the 1929 Manual.

Appendix C

(5) APPLICATION OF UNIT HEATERS TO SHOPS AND LOCOMOTIVE TERMINALS

B. M. Murdock, Chairman, Sub-Committee; H. G. Dalton, Benjamin Elkind, A. T. Hawk, L. C. Hinsch, A. S. Kent, L. H. Laffoley, H. C. Lorenz, V. B. W. Poulsen, John Schofield, M. J. T. Zeeman.

General

Before the development of unit heaters, the customary method of industrial heating was accomplished by the use of direct steam or hot water radiation or the centralized fan system of hot air heating.

To simplify the piping and conserve floor space, radiators are usually placed close to the walls. This causes the warm air to rise along the walls to the highest point of the building with the result that the warmest part of the building is under the roof and adjacent to the radiators along the sidewalls, while the temperature in the center of the building is usually much lower.

To correct this unequal distribution of heat, the central fan system of hot air heating was developed. This system consists of a large fan blowing or drawing air through a bank of heating coils, the heated air being distributed to different parts of the building through ducts or pipes.

This system is an improvement over the direct radiation or pipe coils as it maintains a more uniform temperature throughout the building. However, the large air ducts required obstruct light, interfere with crane clearances, and are very expensive. While the objection of interference can be overcome by placing the ducts underground, this procedure further increases the expense, both in first cost and also in operating cost, due to heat losses through the ground.

To overcome the limitations of these two systems in the field of industrial heating, a method of de-centralized hot air heating was developed through the use of small fan heaters which could be located at different points throughout the building. These small heaters have been developed in many different types under the caption, "Unit Heaters."

The chief advantages of unit heaters over direct radiation are that they circulate the air in buildings, reduce condensation, promote uniformity of temperature, permit quick heating up, reduce the number of heating fixtures, simplify piping and installation, and provide a system which is readily controlled, either automatically or manually. Their advantage over the centralized fan system is in the elimination of expensive duct work. When desired, the unit heaters may also be used as a means of improving working conditions by circulating the air in the buildings during the hot summer weather. For these reasons, unit heaters are very adaptable to all shop and locomotive terminal buildings.

Description

The unit heater is composed of a heating unit or radiator enclosed in a housing in which electrically driven fan or fans of either the propeller or centrifugal type are mounted. The fans draw or force the air through the heating unit or radiator, discharging the heated air into the room at various velocities. The directional flow of the air is controlled by dampers, louvers, screens or short ducts.

The items comprising the various types of unit heaters and the materials of which they are made vary considerably with the different ideas of the manufacturer. In general, the heating element consists of seamless copper or brass tubing, with copper fins helically wound around them. The tubing is fused or screwed into headers of cast brass, cast bronze, cast aluminum, cast iron or cast steel. These units are tested under hydrostatic pressures varying from 250 to 1000 pounds per square inch.

The fans are made of either sheet steel or some kind of corrosion-resisting material. The disc or propellor type is mounted behind the heating shaft, and with this type the fan and motor are located behind the heating unit and in the path of the air current. The centrifugal type is mounted on a shaft extending the full length of the heater and the motor is located on a bracket to one side and out of the path of the air current, but in this type the fan casing must have sufficient strength to properly support the bracket.

Motors are of standard design and of constant or variable speed as may be desired. They are either open or fully enclosed, depending upon the type of fan. The open type are usually used with the centrifugal fan and the fully enclosed with the propellor type.

They are equipped with ball, roller or sleeve bearings and also with thrust bearings when used with propellor type fans.

Types of Unit Heaters

Several different types of unit heaters are available, floor types with air up-take and horizontal discharge, suspended type with horizontal discharge, and ceiling types with vertical downward discharge. They are made with single or multiple outlets. In single outlets, the air can be discharged in only one direction, but the multiple outlet type will permit air to be discharged in two or more directions. Heaters are designed for use with low or high pressure steam, hot water, gas, and electricity. In the gas unit, the heating medium consists of a gas burner that passes the products of combustion through tubes, which transfer heat directly to the air. The electric units are similar in design to the other types, with the exception that in this case an electric heating element is substituted for the steam or hot water radiator in the other types.

Selection of Heating System

As previously stated, unit heaters may be used with either low or high pressure steam, hot water, gas or electric systems of heating, the system chosen usually being dictated by local conditions. On account of the fewer number of unit heaters which would be required by the use of steam, it is generally conceded to be the most economical system to use. There are, of course, exceptions, such as cases where long runs of supply and return piping would have to be constructed and maintained so that the use of steam would not prove as economical as gas or electricity, if they were available. Whenever gas heaters are used, care must be taken to see that they are properly vented to the outside atmosphere.

A high pressure steam system is cheaper in first cost, for fewer unit heaters and smaller piping will be required as compared to a low pressure steam system, which requires more unit heaters and larger supply and return piping. Operating at lower temperatures, however, gives more uniform and efficient heating, and the operating economies thus effected will offset the difference in first costs. The higher the air temperature being discharged through the heater, the greater the tendency for the air to collect in the upper part of the building. This results in a lack of sufficient heat in the working part of the building and a material waste of heat by excessive losses through the roof and upper exposures.

The two most common systems employed are the low pressure two pipe system and the low pressure vacuum system.

Size and Selection of Unit Heaters

The number and size of the unit heaters is determined by computing the heat losses from the building as is done in all heating problems. If it is intended to only re-circulate the air and not provide for any air changes, the calculations will be made in the same manner as for direct radiation. If all or a portion of the air is to be taken from the outside, the heat necessary to bring this air up to the temperature of the inside air must be added to the transmission or other losses. The number and sizes of heaters will then be determined by the number of air turnovers desired and the temperature required. The greater the number of air turnovers the better the results, because the unit heaters can operate at lower outlet temperatures with the result that the air does not rise to the upper part of the building as rapidly as would be the case with higher outlet temperatures. Operating at lower temperatures with a greater number of air turnovers permits more economical operation through a saving in fuel. The number and size of

heaters may be obtained from the manufacturers' rating tables which are based on the steam pressure to be used and the temperature at which the air will enter the heater.

Steam at two lb. pressure and air entering at 60 deg. Fahr. are used as the standard basis of rating.

Where air is taken from the outside at a temperature below freezing, the steam pressure on the heating surface should be not less than five lb.

The different kinds of unit heaters now available may be divided into two classes—suspended type and the floor type.

With the suspended unit heater it is possible in many instances, where clearances will permit, to use overhead return lines and avoid the expense of pipe trenches and underground lines in basements or in single story buildings without basement.

In some cases the use of overhead return lines, where the run is short and sufficient elevation obtains, will permit dispensing with a basement boiler room. In determining this feature, the manufacturers' published recommendations for piping should be closely followed.

Off-setting the above advantages is the fact that the suspended type of heater is required to force the heated air down to the working zone, which is contrary to the laws of nature. Therefore, the higher the unit is above the floor line, the greater will be the volume and velocity required to bring the heated air down to the working zone.

The floor type unit heaters can be operated more economically because they take full advantage of the laws of nature. In this type, the cool air from the floor is drawn in through the air intake at the floor line and after passing through the heater is discharged just above the head line. This keeps the warm air circulating within the working zone and lessens the tendency for the heated air to accumulate in the upper portion of the building. This is a very important feature in buildings where overhead cranes are used, for the working conditions of the crane operators must be considered.

In the case of existing buildings where the piping is overhead, or where other conditions require the use of suspended unit heaters, greater fuel economy will result if they are equipped with re-circulating ducts through which air can be drawn from the floor level.

Location of Heaters in Shop Buildings

The heaters should be so located that the heated air will not be discharged any higher above the floor line than is absolutely necessary. The ideal location is to place the bottom of the warm air discharge about ten feet above the floor line. This provides head room where suspended heaters are used, and in both types permits discharge of heated air above the heads of the occupants. The unit heaters may be located in practically any part of the building, provided the inlet and discharge are free and unobstructed. As a general rule, the heaters should be placed in such a position that the heated air will be discharged toward the exposed walls of the building.

Unit Heaters for Engine Houses

The use of unit heaters in engine houses presents a different problem from that of the ordinary type of shop building. In engine houses, better results are obtained by reversing the procedure, that is, by placing the cool air intake at the top of the working zone and discharging the heated air through ducts into the pits or at the floor line. If this is not done and the cold air taken from the floor line, there will be an excessive inflow of cold air with the opening of the engine house doors, and this cold air seeking the lowest level creates an objectionable condition in the pits and at the floor line. This objectionable condition is further increased by the loss of warm air through the

smoke jacks and roof ventilators, which work against the heaters and prevent the warm air being brought down to the floor line and re-circulated.

The heaters and ducts should be constructed entirely of corrosion-resisting materials in view of the sulphur gases to which they will be subjected. The intake of the heater should be located not more than seven to ten feet above the floor in order to avoid the circulation of gas laden air which tends to collect in the upper part of the building.

Satisfactory results are obtained with heaters located beneath the floor in a small extension on the rear end of the engine pit. In such installations, a grating is provided in the engine house floor through which the cool air is drawn into the chamber, passed over the heater coils and discharged into the pit. Heaters located in this manner, however, will require underground piping and, in addition, they are subject to damage from the possibility of water backing up in the pits or when floors are being flushed down and they should therefore be equipped with fully enclosed and waterproof motors.

The fans should be manually controlled, so they may be shut off if desired by the men working in the pits. Heaters placed above the floor with ducts leading into the pits may be equipped with a damper in the duct, so warm air may be diverted from the pit when desired and discharged above the floor line.

Unit heaters are particularly well adapted to engine houses where direct steaming is used. Under these conditions it is not always necessary to provide a heating plant of sufficient capacity to heat the entire house. A certain amount of radiant heat is given off by the locomotives under steam, and the elimination of smoke jacks greatly reduces the heat losses. Under some conditions, this is sufficient to justify omitting the heating plant entirely. This, of course, depends on climatic conditions and the number of locomotives which will be in the house at one time and under steam. Where the heat from locomotives will not provide for satisfactory working conditions, the deficiency can very readily be made up by utilizing unit heaters. They can be individually operated as the occasion demands, thereby providing a very flexible and economical method of heating.

Automatic Control

There are two general methods of control that may be used. One is to control the fan or fans individually or in groups by the use of room thermostats. The other is to also control the steam supply to the individual or group of units by a thermostatically controlled steam valve. This method of control is sometimes provided to protect workers near the heater from discomfort caused by the radiant heat expelled by the heater coils.

Quietness of Operation

Consideration should be given to the degree of quietness required for the individual operation. Fan speed cannot be considered as a measure of quietness for fans of different design and sizes. Quietness is a function of kind, diameter, shape of blades and other variables beside speed, and all these must be given consideration.

REPORT OF SPECIAL COMMITTEE ON CLEARANCES

A. R. WILSON, Iron and Steel Structures *(Chairman)*;
J. E. ARMSTRONG, Assistant Chief Engineer, Canadian Pacific Railway (representing Canadian Practice);
H. AUSTILL, Wooden Bridges and Trestles;
C. W. BALDRIDGE, Roadway;
R. C. BARDWELL, Water Service and Sanitation;
E. H. BARNHART, Rules and Organization;
H. M. BASSETT, Electricity;
J. G. BRENNAN, Grade Crossings;
P. M. GAULT, Signals and Interlocking;
C. R. HARDING, Track;
M. HIRSCHTHAL, Masonry;
L. P. KIMBALL, Shops and Locomotive Terminals;
H. L. RIPLEY, Yards and Terminals;
A. L. SPARKS, Buildings;

Committee.

To the American Railway Engineering Association:

Your Committee respectfully submits the following as its report.

Outline of Proposed A.R.A. Box Car (Fig. 6).

Clearance diagram for Pantagraph (Fig. 7).

The clearance diagram for pantagraph, as shown by Fig. 7, is for car on tangent track and includes an amount due to sway of car. On curved track the clearances shall be increased, due to superelevation of rail.

Action Recommended

That these diagrams, Fig. 6 and 7, be received as information.

Respectfully submitted,

THE SPECIAL COMMITTEE ON CLEARANCES,
A. R. WILSON, *Chairman.*

Bulletin 350, October, 1932.

OUTLINE DIAGRAM - PROPOSED A.R.A. STANDARD BOX CAR

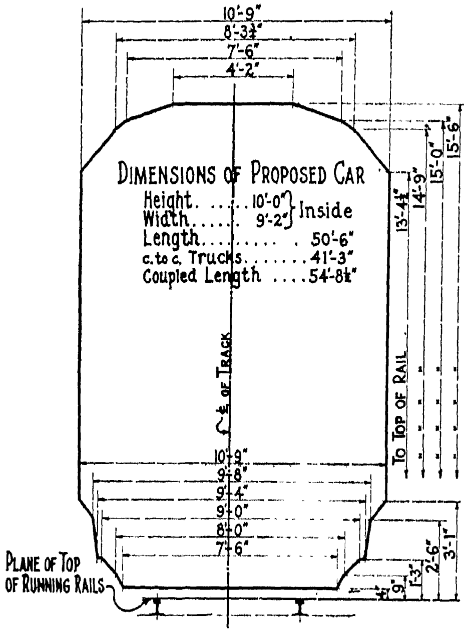


FIG. 6

PANTOGRAPH CLEARANCE

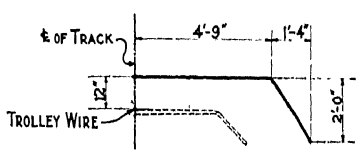


FIG. 7

REPORT OF COMMITTEE X—SIGNALS AND INTERLOCKING

P. M. GAULT, *Chairman;*
F. H. BAGLEY,
G. H. DRYDEN,
W. J. ECK,
W. H. ELLIOTT,
J. V. HANNA,
C. R. HODGDON,
C. A. MITCHELL,
J. C. MOCK,
R. D. MOORE,
H. G. MORGAN,
H. H. ORR,
J. A. PEABODY,
F. W. PFLEGING,
W. M. POST,
A. H. RUDD,
C. H. TILLETT, *Vice-Chairman;*
F. S. SCHWINN,
T. S. STEVENS,
E. G. STRADLING,
W. M. VANDERSLUIS,
F. B. WIEGAND,
LEROY WYANT,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) Report developments of automatic train control, collaborating with Train Control Committee, A.R.A. (Appendix B).

(3) Developments of automatic highway crossing protection, collaborating with Committee IX—Grade Crossings. A designated member of your Committee has collaborated as requested.

(4) Increased efficiency secured in railway operation by signal indication in lieu of train orders and timetable superiorities, collaborating with Committee XXI—Economics of Railway Operation (Appendix C).

(5) Synopsis of the principal current activities of the Signal Section, A.R.A., supplemented with list and references by number of adopted specifications, design and principles of railway operation (Appendix D).

(6) Furnish the Special Committee on Clearances the information required by it pertaining to signals and interlocking. A designated member of your Committee has collaborated as requested.

(7) Possibility of providing suitable protection at less cost than the present-day practice for both construction and maintenance of signals and interlocking (Appendix E).

(8) Report on use of flashing lights in railway signals (Appendix F).

Action Recommended

1. That Appendix A be approved.
2. That Appendix B be received as information.
4. That Appendix C be received as information.
5. That Appendix D be received as information.
7. That Appendix E be received as information.
8. That Appendix F be received as information.

Respectfully submitted,

THE COMMITTEE ON SIGNALS AND INTERLOCKING,
P. M. GAULT, *Chairman.*

Bulletin 350, October, 1932.

Appendix A

(1) REVISION OF MANUAL

W. M. Vandersluis, Chairman, Sub-Committee; J. V. Hanna, W. M. Post, C. H. Tillett.

Reference is made to the 1932 report of the Sub-Committee as found in Vol. 33, No. 343, of January, 1932, on page 510. No action was taken by the Board of Direction on the recommendations made.

Your Committee recommends the voiding of all Signal Section matters now in the A.R.E.A. Manual and Supplements, and the printing in the next supplement to the Manual of a complete index to the Signal Section Manual as furnished by the Secretary of the Signal Section.

Your Committee further recommends that notice of changes only be made each year in future supplements to the A.R.E.A. Manual and that the complete current index be printed only when the A.R.E.A. Manual as a whole is revised.

Appendix B

(2) DEVELOPMENTS OF AUTOMATIC TRAIN CONTROL

W. H. Elliott, Chairman, Sub-Committee; F. W. Pfleging, W. J. Eck.

Sub-Committee No. 2, which has the assignment "Report Developments of automatic train control, collaborating with Train Control Committee, A.R.A.", has reported on the progress made each year.

The total mileage of automatic train control has been reduced by 471 track miles, the number of equipped engines reduced by 123, and the number of equipped motor cars by 5.

Nothing new has been developed in the matter of interchangeability and the Committee will continue its studies.

The petition of the Great Northern for relief from maintaining and operating its train control installation was approved by the Interstate Commerce Commission to the extent of suspending the order until further orders of the Commission. This was done on a finding that "in view of the low traffic density, the favorable physical characteristics of the road and terrain, the relative moderate rates of speed, the record of safety, and the freedom from accidents of the character which this device is designed to prevent. At the present time operating conditions on these divisions do not require the maintenance and operation of automatic train stop devices."

The petition of the Northern Pacific was approved by the Interstate Commerce Commission after hearing at which officers of the Company testified that on account of the reduced train service, favorable operating and weather conditions between Mandan, N. D., and Glendive, Montana, where the device was in service, the railroad was not justified at the present time in keeping the device in service. That the money expended for maintenance of automatic train control equipment could be used more effectively in other ways to promote safety.

The approval of the Commission to the removal of the train control installation is as follows:

"Upon this record, in view of the low traffic density, the favorable physical characteristics of the road and terrain, the relatively moderate rates of speed, the record of safety, and the freedom from accidents of the character which this device is designed to prevent, we find that at the present time operating conditions in the territory between Mandan and Glendive do not require the continued maintenance and operation of automatic train stop devices, and therefore our orders of June 13, 1922, and Janu-

ary 14, 1924, as amended, insofar as those orders apply to petitioner, are suspended until our further order."

The petition of June 20, 1932, of the Union Pacific for it to be permitted to operate its locomotives equipped with automatic cab signals in lieu of automatic train control stop or train control devices was approved by the Interstate Commerce Commission after hearing at which officers of the Company testified "that no element of safety would be sacrificed by substituting a cab signal system for the existing automatic train control installation, and that a material reduction in expenditures required for maintenance and operation could be effected thereby."

It was testified by Union Pacific officials that "Since January, 1926, there have been four train collisions on the Union Pacific Railroad, one of them in automatic train control territory and three in automatic block signal territory. After a study of the circumstances in each of these cases, it is the opinion of the Signal Engineer for the Union Pacific that the proposed cab signal system would have furnished as much protection as automatic train control, except that in one instance, the engineman being killed as a result of the accident, sufficient information was not available to form a definite opinion and it is a matter of conjecture whether either automatic train control or a cab signal system would have prevented this accident."

The approval of the Commission to the request of the Union Pacific to eliminate the train control feature of the installation and retain only the cab signal feature is as follows:

"Upon this record we find that our order of June 13, 1922, and January 14, 1924, as amended, insofar as those orders affect the petitioner, should be modified to permit petitioner to use on its line between North Platte, Nebr., and Cheyenne, Wyo., an automatic cab signal system in lieu of automatic train stop or train control devices as now required by said orders. The specifications and requirements for automatic train stop or train control devices which were prescribed by our order of June 13, 1922, are not applicable in their entirety to automatic cab signal devices and specifications and requirements for a continuously controlled automatic cab signal system for installation and operation by the Union Pacific Railroad Company in lieu of automatic train control devices will be prescribed."

The approval given by the Commission for the changes requested by the Great Northern, Northern Pacific and Union Pacific is provisional only. Should conditions arise making it advisable to restore the train control device to service orders to this effect will be issued by the Commission.

The following roads have filed petitions for relief from maintaining automatic train control:

Chicago, Burlington & Quincy
Texas & New Orleans
Missouri Pacific
Chicago, Rock Island & Pacific (2nd order only)
Delaware & Hudson

The Bureau of Safety is continuing to make periodical visits to each installation for the purpose of observing maintenance methods, and to effect an interchange of ideas with respect to various matters associated with automatic train control. Effective July 1, 1932, the carriers were permitted to discontinue reporting certain items of information required on the monthly report of train control performance, thus relieving them of considerable work in this connection.

Although cab signals were in use on the Pennsylvania Railroad on the Lewiston Branch in 1923 and continuously in use from July, 1926, to date, definitions and specifications covering their use were first made a part of a proceeding with respect to an installation of automatic train control under order 13413 during the past year. At the

hearing on the petition of the Union Pacific Railroad to be permitted to remove the automatic brake applying apparatus, and operate by means of cab signals and wayside signals, these definitions and specifications, which have been approved by the Committee on Automatic Train Control, were introduced into the testimony.

The definitions and specifications now issued by the Interstate Commerce Commission as an order are the same, with exception of the numbering of certain paragraphs and the elimination of a provision permitting operation without fixed signals, as those presented to the Signal Section in May, 1931, as tentative specifications and requirements which were prepared by Interstate Commerce Commission Engineers, Train Control Committee of A.R.A., and a number of Signal Engineers. No. 6 in the Commission's order reads: "The automatic cab signal system shall be so interconnected with the fixed signal system that the cab signal will display indications consistent with the indications of the fixed signals, except when a fixed signal displays a less restrictive indication that is required or warranted by existing conditions."

The Committee on Automatic Train Control and the Bureau of Safety are cooperating in special tests and investigations, and have completed a series of tests to determine the efficiency of strap iron inductors used instead of the regular laminated type, where a winding is not necessary. It was determined that while the efficiency of the former is less than the latter, the strap iron type is satisfactory for round house and terminal departure tests, and with one type of locomotive equipment may be safely used for main track operation.

Appendix C

(4) INCREASED EFFICIENCY SECURED IN RAILWAY OPERATION BY SIGNAL INDICATIONS IN LIEU OF TRAIN ORDERS AND TIMETABLE SUPERIORITIES

W. M. Post, Chairman, Sub-Committee; G. H. Dryden, W. J. Eck, P. M. Gault, C. A. Mitchell, W. M. Vandersluis.

Committee X at the 1932 annual meeting presented a report on the progress made in the installation of centralized traffic control (CTC), listing the installations and the economic results.

At the meeting a supplementary report with lantern slide illustrations was presented relating to CTC on the Missouri Pacific and Pennsylvania Railroads.

This report relates to the economic results of the Missouri Pacific installation.

CTC on the Missouri Pacific

The Missouri Pacific on December 30, 1929, placed in service a centralized traffic control system on the Omaha Division on 43 miles of single track between Kansas City (Edgewater Junction) and Atchison, Kansas. In this territory train movements are now directed by signal indications, superseding timetable superiorities and taking the place of written train orders.

Over this single track line are moved the trains of three different roads; the Missouri Pacific, the Chicago Great Western and the Union Pacific. In the busy season as many as sixty trains per day have been operated.

Centralized traffic control was installed for the purpose of reducing the delays incident to the high traffic density of the line and reducing freight train costs.

The remaining portion of the Omaha Division, 357 miles, is a single track line over which trains are operated by timetable schedule, train order and manual block.

Traffic Density

The CTC section, (43 miles of single track), with its high traffic density, was the "bottle-neck" of the Omaha Division.

Traffic Density. Net Ton Miles (Revenue and Non-Revenue) per Mile of Road per annum for the Year 1930

	(Thousands)
Omaha Division, *not* including the CTC Section	1,436
CTC Section, between Leavenworth and Atchison, 20 miles	4,456
CTC Section, between Kansas City and Leavenworth, 23 miles (includes the C.G.W. trains)	6,371

Other Traffic Densities, 1930

United States, Class I railways	1,424
Missouri Pacific Railroad	1,612
Norfolk & Western Railway	6,688
Chesapeake & Ohio Railway	7,051
Pittsburgh & Lake Erie Railroad	9,347

The above shows that the traffic density of the CTC Section between Kansas City and Leavenworth is in the Norfolk & Western and Chesapeake & Ohio class, and this density for a single track line compares favorably with that of the Pittsburgh & Lake Erie, a multiple track line.

Economic Results

The economic results of the installation of centralized traffic control are shown in Table I. This table shows that on the Omaha Division *not* including the CTC section the saving 1930 over 1929 was $73,232, or 53 per cent of the total saving.

On the CTC section the saving was $65,549, or 47 per cent of the total saving.

This 47 per cent of the total saving was made on only 11 per cent of the total miles of road.

On the centralized traffic control section *only*, the saving in freight train costs plus the saving in block and interlocking stations discontinued made a total annual saving of $93,149. After deducting the annual expenses and interest charges, the net saving on the CTC section amounted to $63,349, or a *net* saving per mile of road of $1,473 (see Table 1).

The savings per mile of road as shown in the table make an interesting comparison. The saving per mile of road on the Omaha Division *not* including the CTC section was $205 as against a gross saving per mile of road on the CTC section of $1,524, or a net saving of $1,473 (see Table 1).

TABLE 1—ECONOMIC STATEMENT, MISSOURI PACIFIC RAILROAD, OMAHA DIVISION

(A) Omaha Division, Saving in Freight Train Costs, (Accounts 392–402). 1930 over 1929

	Total Saving		*Miles of Road*		*Saving*
	Amount	*Per Cent*	*Miles*	*Per Cent*	*Per Mile*
Omaha Division *not* including CTC section	$ 73,232	53%	356.9	89%	$ 205
CTC section only	65,549	47%	43	11%	1,524
Omaha Division *including* CTC section	$138,781	100%	399.9	100%	$ 347

(B) Centralized Traffic Control Section only, 43 Miles, Saving in Freight Train Costs and Saving in Block and Interlocking Stations Discontinued, 1930 over 1929

	Total Saving	*Saving per Mile*
Saving in freight train costs	$65,549	$1,524
Saving in block and interlocking stations discontinued	27,600	642
Total saving on CTC section	$93,149	$2,166
Less annual expenses and interest charges	29,800	693
Net saving 1930 over 1929	$63,349	$1,473

Comparison of the Omaha Division with the CTC Section

This comparison of the freight train performance and costs of the Omaha Division with the CTC section is shown in Table II.

The basic data, averages and saving are shown under two heads:

Omaha Division, including CTC section.

Centralized traffic control section only.

Under basic data are the figures for—

- Gross ton miles
- Train miles
- Train hours
- Freight train costs
- Miles of road

Under averages—

- Gross tons per train
- Train miles per train hour (speed)
- Gross ton miles per train hour
- Cost per train hour
- Cost per 1000 gross ton miles

Under saving—

- Saving per 1000 gross ton miles
- Saving 1930 over 1929.

The significant figures are the averages. The averages for the CTC section show a greater percentage of improvement than the averages for the Omaha Division. For example, on the Omaha Division the cost per 1000 gross ton miles is decreased 12 per cent, whereas on the CTC section it is decreased 39 per cent. This is accounted for by the increase in the gross ton miles per train hour on the division of only 8 per cent as against an increase on the CTC section of 57 per cent.

The improvement in the freight train performance of the Omaha Division, 1930 over 1929, effected a total saving of $138,781, reducing freight train costs by 12 per cent. Of this saving, 47 per cent is due to the improvement in train operation through the CTC section, and as there was no increase in the locomotive tractive effort full credit should be given to the CTC installation for the increased efficiency in operation secured through the use of signal indications in lieu of train orders and timetable superiorities. Some 50,000 train orders per year were eliminated.

Cost of the CTC Installation

The cost of the installation including track changes was............	$430,000
The net saving per annum was..................................	63,349

In addition to this net saving, the construction of double tracking was postponed.

Summary (CTC section)

Gross tons per train increased 6 per cent.
Train miles per train hour (speed) increased 47 per cent.
Gross ton miles per train hour increased 57 per cent.
Cost per 1000 gross ton miles decreased 39 per cent.
Locomotive tractive effort 72,300 lbs., no change.
Net return on total investment 14.7 per cent.

This installation of CTC on the Missouri Pacific, judged by the improvement in freight train performance and the decreased freight train costs, may be regarded as a notable example of a self-liquidating project.

Appendix D

(5) SYNOPSIS OF THE PRINCIPAL CURRENT ACTIVITIES OF THE SIGNAL SECTION, A.R.A., SUPPLEMENTED WITH LIST AND REFERENCES BY NUMBER OF ADOPTED SPECIFICATIONS, DESIGNS AND PRINCIPLES OF SIGNALING PRACTICE

E. G. Stradling, Chairman, Sub-Committee; H. H. Orr, Leroy Wyant.

CURRENT ACTIVITIES OF THE SIGNAL SECTION A. R. A.
SINCE MARCH, 1932

(As of November, 1932)

The Signal Section has investigated and made reports covering the following:

1. Reflecting devices as a substitute for oil and electric lights but no conclusions reached.
2. Information as to practices and requirements of various states in connection with highway grade crossing protection.
3. Revised instructions for installation, maintenance and operation of lead acid type storage batteries.
4. Revised instructions for installation, maintenance and operation of nickel, iron and alkaline storage batteries.
5. Revised instructions for maintaining and testing interlocking plants.

Investigations and recommendations have been made on the following facilities to effect economies in railway maintenance and operation:

a. Grade or tonnage signals.
b. Electric lighting of signal and switch lamps.
c. Replacing manual highway grade crossing protection by automatic, automanual or centralized control.
d. Automatic block signals where manual block, train staff or time interval spacing of trains is used.
e. Manually operated interlockings.
f. Consolidation of interlocking plants.
g. Automatic interlocking.
h. The use of remote control for outlying signals and/or switches.
i. The operation of trains by signal indications.
j. Centralized traffic control.
k. Car retarders.

SPECIFICATIONS REVISED

	Old No.	*New No.*
Installation of Electric Interlocking	6528	6532
Power Interlocking Machine	7630	7632
Air Cooled Reactor for Line and Track Circuits	10420	10432
Impedance Bond	7417	7432
Alternating Current Generator	7319	7332
Direct Current Generator	1411	1432
Galvanized E.B.B. Steel Bonding Wires	2211	2232
40% Conductivity Copper-Covered Steel Bonding Wires	7018	7032
Rubber Insulating Tape. Section 2–c	5616	5632
Aerial Braided Cable. Section 7–c–1	8930	8932
Armored Submarine Cable. Section 9–c–1	9031	9032
Lead Covered Cable. Section 8–c–1	9131	9132
Mineral Matter Rubber Compound Insulated Signal Wire. Section 4–c–1	11129	11132
Parkway Cable. Section 11–c–1	14529	14532

NEW SPECIFICATIONS

	New No.
Electro-Pneumatic Switch Operating Mechanism	15232
Tractive Armature Direct Current Neutral Relay for Series Line Approach Lighting	15432

REVISED REQUISITES

Impregnating Compound Treatment of Electrical Windings.
Varnish treatment of Electrical Windings.
Requisites for Direct Current Automatic Block Signaling Circuits.

SPECIFICATIONS TO BE REMOVED FROM MANUAL

Switch Board Material #6217.
Underground Braided Cable for 660 volts or less #9420.

REQUISITES TO BE REMOVED FROM MANUAL

Choke Coils for Signaling.
Light Signals for Day and Night Indications.
Sheet for Switchboard Material.

Appendix E

(7) POSSIBILITY OF PROVIDING SUITABLE PROTECTION AT LESS COST THAN THE PRESENT DAY PRACTICE FOR BOTH CONSTRUCTION AND MAINTENANCE OF SIGNALS AND INTERLOCKING

F. B. Wiegand, Chairman, Sub-Committee; H. G. Morgan, J. C. Mock, J. A. Peabody, T. S. Stevens, F. H. Bagley, G. H. Dryden, C. R. Hodgdon.

HISTORICAL

The difference in the cost of modern signaling, or present-day practice, as referred to in the assignment, as compared with the signaling installed some thirty years or more ago, is due to its modernization account of keeping abreast of the times and is in line with the progress made generally in both rolling stock and maintenance of way equipment. Originally signals were wire-connected and their proper operation questionable. On account of this questionable operation the signals within interlocking limits were pipe-connected and the distant signals were changed to power-operated signals, and later, for the purpose of obtaining greater visibility, the signals were lighted electrically instead of with oil lamp; they, for the purpose of obtaining still greater visibility, and the development in the art permitting, are now being changed to color light, position light or color position light. Higher wages and higher prices of materials are factors which should also be considered.

For safety reasons at interlockings, detector bars and crossing bars were installed to prevent the operation of switches under trains or the changing of the route while train was occupying the crossing. To provide additional protection electric locking in lieu of detector bars came into vogue; this became a necessity with the advent of heavier rail, which, on account of the increase in width of head, eliminated all of the protection previously afforded. To provide still greater protection the electric locking was added, and it became known as route locking. Route locking not only prevents the operation of switches under trains, but also prevents their operation in advance of trains, after the route has been set up and the signal, which was cleared, returned to its normal position, until the expiration of a predetermined period of time. This was followed by release electric locking which is a modification of the straight route locking in that it permits the changing of the route as the rear of train, passing through the interlocking, clears the turnout or crossover switches and fouling point. Release electric locking is usually installed at interlocking plants where time is a factor.

State Requirements

In addition to the foregoing there are the requirements of the State Commissions which have to be met. Some states require derail protection; others require smash-

board signals at crossings. These requirements add to both construction and maintenance cost and are not the recommended practice of the Signal Section, A.R.A.

Recommended Practice

The Signal Section is on record as not recommending smashboards. Its recommendation regarding derails reads:

> "Derails should not be used in main tracks. On heavy grades, where the need of some device to check run-away trains or cars is indicated, properly designed deflecting tracks may be used."

Construction Cost

Having a track layout approved by all interested departments before drawing detailed signal plans, ordering material or starting construction, is a very important item in keeping the cost of signal construction to a minimum. Minimum requirements should be determined; all unnecessary switches within the interlocking limits should be eliminated, which elimination at times can be accomplished by some slight rearrangement of crossovers or perhaps changing their location. Locating the signals and interlocking units close to the tower should also be considered. By all means avoid making changes after the signal engineering has been completed as even the reversal of a crossover may upset all calculations; it surely involves redrawing all signal plans.

The labor cost of construction is now being kept as low as possible by the use of power tools where practicable and by the employment of unskilled labor for the performance of such parts of the installation as does not require the higher class of labor. In addition, newly developed materials, such as parkway and trench-lay cable, for use in lieu of single conductor wires in trunking mounted on stakes, is being considered. The material cost is kept down by the use of translating devices and other material less expensive than those used for circuits involving safety where safety is not affected.

Consideration has been given and in some cases a universal switch layout, which permits the switch being interlocked or hand-operated without change in tie spacing, tie plates, tie bars, rail braces and other switch fittings, has been adopted. This item materially reduces not only the construction cost of signaling, but also the maintenance cost of both.

Considerable work has been done along the line of standardization and the Signal Section is still active in this respect.

Maintenance Cost

To keep the cost of maintenance low, the essential thing is that we build soundly and solidly. This involves the use of first-class material and that the work be installed in first-class manner; it also involves supervision, that will enable the supervisory force to get in touch with the maintenance force, at least once each month, to issue verbal advice and instructions.

The reclamation of materials is an important item; not all materials should be reclaimed but only such as can be rehabilitated at less cost than it can be purchased for new. In addition, the cost of repairs to material in the field and the cost of such repairs in the shop must be compared, and, when cheaper to repair in the shop, it should be done in the field only in emergency. The use of materials which involve the least maintenance is also important.

Another important item is the question of reports. The making out of reports takes considerable of the maintainers' time and, if these can be reduced to a minimum, it will undoubtedly result in decreased maintenance force and corresponding reduction in maintenance cost. Instead of distributing his time and material used to the various facilities, the maintainer should only be required to report his time. Material required should be charged out to the section when furnished by the Stores Department. The

accountant in the office should charge both time and material to the proper accounts in percentages previously established. These percentages are established on a unit basis of A.R.A. values, each facility on a section being charged with the percentage which the number of units of the facility bears to the entire number on the section.

Summary

The recommendations of your Committee are as follows:

To Lower Cost of Construction

Determine minimum requirements and have all interested departments approve the plan of the track layout.
Adopt universal switch layout.
Standardize signaling material.
Use power tools where practicable.
Use unskilled labor for unskilled work.
Use modern material.
Use apparatus of lower standard of excellence where safety is not involved.
Omit derails.

To Lower Cost of Maintenance

Build soundly and solidly.
Employ ample supervision.
Reclaim materials that may be reclaimed at less cost than new.
Omit reports where practicable.
Omit derails.

Appendix F

(8) REPORT ON USE OF FLASHING LIGHTS IN RAILWAY SIGNALS

F. S. Schwinn, Chairman, Sub-Committee; C. H. Tillett, R. D. Moore, J. A. Peabody, A. H. Rudd, E. G. Stradling.

Your Committee has canvassed a selected list of thirty railways from which twenty-seven replies were received. Only three railways advise that they are now using flashing lights to govern or control the movement or operation of trains. Railways reporting the use of such flashing lights advise as follows:

MISSOURI PACIFIC RAILROAD: Flashing lights are used in train order signals where the light is near enough in line with some other signal light to result in possible confusion of signals at night or during bad weather conditions. Such lights are covered by bulletins when installed.

PENNSYLVANIA RAILROAD: At certain interlocking stations where the train at or near the home signal is not in sight of the cabin, or at multiple track interlockings, yellow flashing lights are used in delivering "19" orders that do not restrict the superiority of the train addressed at that point. Such lights are covered by a special rule.

SOUTHERN PACIFIC COMPANY: Two flashing light installations are in use, not as running signals but for special purposes. In one case the flashing light is used at the entrance to a yard for the purpose of instructing incoming freight trains whether they are to proceed into the yard or stop and wait. In the other case, the flashing light is mounted on the mast of an interlocking signal and is used in lieu of a hand signal by the towerman where such hand signal cannot be seen by the engineman. In both cases, the flashing signals are used to avoid confusion with automatic signal indications and are covered by special instructions.

MICHIGAN CENTRAL RAILROAD: The flashing red light is used to indicate "Freight Trains Take Siding". Such signals display one indication only and do not supersede the superiority of trains nor dispense with the use or observance of other signals. The take siding signals may be located on masts below the arms or lights of block signals and the indication "Freight Trains Take Siding" is given by the display of a flashing or winking red light. Special rules governing are in use.

Conclusion

The Committee feels that the restricted use of flashing signals under special rules or instructions is permissible at selected points.

REPORT OF SPECIAL COMMITTEE ON WATERPROOFING OF RAILWAY STRUCTURES

J. A. LAHMER, *Chairman;*
G. E. BOYD,
O. F. DALSTROM,
HUGO FILLIPPI,
L. V. HAEGERT,
A. C. IRWIN,
F. R. JUDD,
A. H. MORRILL,
G. A. RODMAN,
I. L. SIMMONS,
F. P. TURNER,
G. A. HAGGANDER, *Vice-Chairman;*
L. W. WALTER,
H. T. WELTY,
C. A. WHIPPLE,
Committee.

To the American Railway Engineering Association:

Your Committee presents herewith its report covering the following subjects:

(1) Definitions. Nothing to report.

(2) When to waterproof or dampproof and methods to be used. The Committee reports progress.

This subject includes a study of the different structures and conditions to which recognized methods of waterproofing and dampproofing are adapted and has received attention but study has not reached point where a report can be made.

(3) Waterproofing and dampproofing as applied to existing railway structures. No report.

(4) Specifications for membrane waterproofing of concrete work, excepting roofs of buildings (Appendix A).

Preparation of these specifications has been underway for several years and they are now submitted as a progress report with the request that the Committee be given the benefit of comments and criticisms by the members of the Association. Specifications which were adopted by the Association in 1927 for waterproofing of solid floor railway bridges have been extended to apply to all concrete railway structures (except roofs of buildings) and an effort has been made to revise them to conform to present day practices.

Action Recommended

(4) That the specifications submitted be received as information.

Respectfully submitted,

SPECIAL COMMITTEE ON WATERPROOFING OF RAILWAY STRUCTURES,

J. A. LAHMER, *Chairman.*

Appendix A

SPECIFICATIONS FOR MEMBRANE WATERPROOFING

Scope

1. These specifications are for use on bridge decks, backs of abutments and retaining walls, tops and backs of culverts, subways, tunnels, conduits, foundations for buildings, walls and floors of basements and pits, tanks, reservoirs, dams and any other structure or part of a structure (except roof of a building).

Design

2. Structures to be waterproofed shall be so designed that they can be waterproofed by the methods and with the materials specified herein. When the structure to be waterproofed is flexible and supported at intervals on comparatively rigid supports, such as cross girders in a viaduct, special care shall be taken to provide flexibility in the waterproofing membrane over such supports. Care shall also be taken effectively to seal or flash all places where the waterproofing membrane terminates, as along the webs of girders.

Bulletin 350, October, 1932.

Types

3. (A) Two layers of bitumen-treated cotton fabric and three moppings of bitumen.
(B) Three layers of bitumen-treated cotton fabric and four moppings of bitumen.
(C) Two layers of bitumen-treated felt, one middle layer of bitumen-treated cotton fabric, and four moppings of bitumen.
(D) Four layers of bitumen-treated felt, one inside layer of bitumen-treated cotton fabric, and six moppings of bitumen.

4. When greater strength is required additional layers of bitumen-treated cotton fabric shall be applied.

Materials

5. Bitumen shall consist of asphalt or coal-tar pitch. The mopped on material shall be of the same character as that with which the felt or fabric is treated.

6. Asphalt for Saturant and Mopping Above Ground shall be homogeneous and free from water. It shall be the product obtained by the distillation of crude asphaltic base petroleum with steam agitation supplemented, if necessary, with oxidation by air, without the addition of any fluxing material other than a native asphalt or straight steam refined asphaltic residual, during any stage of the process of manufacture. It shall meet the following requirements:

(a) Softening point (ring and ball method).........150° to 170° F. (65.5° to 76.7° C.)
(b) Penetration: at 115° F. (46.1° C.), 50 g., 5 sec................not more than 100
at 77° F. (25° C.), 100 g., 5 sec..........................25 to 40
at 32° F. (0° C.), 200 g., 60 sec..................not less than 10
(c) Flash point (open cup).........................not less than 400° F. (204.4° C.)
(d) Loss on heating at 325° F. (163° C.), 50 g., 5 hr.........not more than 0.5 per cent
(e) Penetration at 77° F. (25° C.), 100 g., 5 sec. of residue after heating at 325° F. (163° C.), as compared with penetration of asphalt before heating.............
....not less than 80 per cent
(f) Ductility: at 77° F. (25° C.) elongated at rate of 5 cm. per min..not less than 20 cm.
(g) at 40° F. (4° C.) " " " " 1 " " ".. " " " 4 cm.
(h) Solubility in carbon disulphide..........................not less than 99 per cent

7. Asphalt for Mopping Below Ground shall be either

A native refined asphalt fluxed with a petroleum flux having a penetration at 77° F. (under a weight of 50 grams for one second) of not less than 350; or,

A petroleum asphalt obtained as a residue by the straight steam refining, without oxidation, of an asphaltic petroleum.

It shall be free of blown or oxidized residuals, cracked residuals, sludge asphalt, or any admixture or derivative thereof, and shall have the following properties:

	Fluxed Native Asphalt	*Petroleum Asphalt*
(a) Specific gravity at 60° F................	1.04 to 1.07	1.03 to 1.06
(b) Penetration at 77° F., 100 grams, 5 sec....	85 to 100	85 to 100
(c) Softening point (ring and ball method)...	110° to 125° F.	110° to 125° F.
(d) Ductility of pure bitumen at 77° F. (25° C.) elongated at rate of 5 cm. per min........	Min. 100 c.m.	Min. 100 c.m.
(e) Flash point	350° F. to 450° F.	Min. 450° F.
(f) Loss on heating	Max. 2.0%	Max. 1.0%
(g) Penetration at 77° F., 100 g., 5 sec., of residue after heating at 325° F. as compared with penetration of asphalt before heating	Min. 60%	Min. 60%
(h) Pure bitumen soluble in carbon disulfide..	Min. 95%	Min. 99½%
(i) Inorganic matter, insoluble	Min. 1½%	...
(j) Paraffine scale (Holde method)..........	Max. ½%	...

8. Coal-tar Pitch for Saturant and Mopping shall be homogeneous and free from water and shall meet the following requirements:

	For Use Above Ground	For Use Below Ground
(a) Specific Gravity at 77°/77° F. (25°/25° C.)	1.25 to 1.35	1.21 to 1.30
(b) Softening point (cube in water method)	130° to 155°F.	110° to 140°F.
(c) Distillation Test:		
Total distillate by weight 32° to 572° F. (0 to 300° C.)	Max. 10%	Max. 15%
Residue by weight	Min. 90%	Min. 85%
(d) Specific gravity, at 100°/77° F. (38°/25° C.) of total distillate to 572° F. (300° C.)	Min. 1.03	Min. 1.03
(e) Ductility at 77° F. (25° C.)	Min. 20 cm.	Min. 50 cm.
(f) Solubility in carbon disulphide	63% to 78%	75% to 90%

9. Asphaltic Primer shall be composed of asphalt (which will conform to either of foregoing requirements for asphalt for mopping) and a solvent, and shall meet the following requirements:

(a) Water	None
(b) Asphaltic Base:	
Per cent of primer by weight, when asphalt meeting requirements of section 6 is used	25 to 35
Per cent of primer by weight, when asphalt meeting requirements of section 7 is used	30 to 45
(c) Solvent (Hydrocarbon distillate):	
End point on distillation	Max. 500° F. (260° C.)
% which shall distill under 248° F. (120° C.)	Max. 20
(d) Sediment	Max. 1%

10. Creosote Oil Primer for use with coal-tar pitch shall conform to the following requirements:

(a) Water	Max. 2.0%
(b) Consistency at 100° F. (38° C.)	Entirely fluid
(c) Specific gravity at 100°/77° F. (38°/25° C.)	1.00 to 1.06
(d) Insoluble in benzol	Max. 1.0%
(e) Distillation Test:	
Total distillate, by weight, under 392° F. (200° C.)	Max. 5.0%
Total distillate, by weight, under 455° F. (235° C.)	Max. 50.0% Min. 30.0%
(f) Residue, by weight, above 671° F. (355° C.)	Max. 15.0%
(g) Specific gravity at 100°/77° F. (38°/25° C.) of the fraction distilling between 455° and 599° F. (235° C. and 315° C.)	Min. 1.00
(h) Consistency at 77° F. (25° C.) of the residue	Soft

11. Fabric shall be high grade cotton cloth thoroughly and uniformly saturated with asphalt or coal-tar pitch for use above ground which conforms to the foregoing specifications.

12. In the process of manufacture, the dry cotton fabric shall be treated thoroughly and uniformly at a temperature and speed that will not injure the fabric. This shall be accomplished by passing the fabric through the saturant and then calendering it in the presence of heat, after which it shall be cooled and wound into rolls.

13. The Untreated Fabric shall contain no oil and shall meet the following requirements:

(a) Thread count in either direction: Minimum 18; maximum 32.
(b) Average weight per square yard: For cloth having 18 to 26 thread count, not less than 5 ounces including not to exceed 6 per cent moisture regain; for cloth having 28 to 32 thread count, not less than 4 ounces including not to exceed 6 per cent moisture regain.
(c) Ash: Not more than one per cent of dry weight of fabric.

14. THE TREATED FABRIC shall meet the following requirements:

(a) Width of roll: Minimum 30 in.; maximum 38 in.
(b) Gross weight of roll: Minimum 35 lb.; maximum 80 lb.
(c) Average weight per square yard: Not less than 11 ounces.
(d) Moisture content: Not more than one per cent of net weight.
(e) Tensile strength at 70° F. in either direction (grab method): Not less than 50 lb. per linear inch.
(f) Elongation without fracture: Not less than 10%.
(g) Pliability at 32° F.: Not less than 10.
(h) Average loss on heating asphalt treated fabric (exclusive of moisture): Not more than 4 per cent.
(i) Weight of saturant in square yard of treated fabric: Not less than one and three-fourths times the weight of a square yard of untreated moisture-free fabric.

15. There shall be sufficient space between the threads of the untreated cotton fabric to allow the saturant to pass through. The surface of the saturated fabric shall be smooth and free from folds, knots, and excess saturant.

16. FELT shall be rag-felt saturated, but not coated, with either asphalt for use above ground or refined coal-tar, or asbestos felt saturated, but not coated, with asphalt, for use above ground. Rag-felt shall be produced by "felting" vegetable and animal fibers.

17. The saturation shall be accomplished by passing the dry felt in single thickness through the saturant at a temperature and speed that will not injure the felt, and then calendering between heated cylinders. It shall then be cooled and wound into rolls.

18. RAG-FELT shall meet the following requirements:

DESATURATED

	Asphalt Saturated	*Coal Tar Saturated*
(a) Average weight of moisture-free felt.....	Min. 5.2 lb. per 100 sq. ft.	Min. 5.2 lb. per 100 sq. ft.
(b) Ash in moisture-free felt...............	Max. 10%	Max. 10%

SATURATED

(a) Width of roll..........................	32 in.–36 in. ± 1/4"	32 in.–36 in. ± 1/4"
(b) Gross weight of roll....................	40–80 lb.	40–80 lb.
(c) Weight of material per 100 sq. ft. exclusive of wrapping and packing...........	14 lbs. ± 1 lb.	14 lbs. ± 1 lb.
(d) Loss on heating at 221° F. (105° C.) for 5 hrs.	Max. 4%	
(e) Moisture	......	Max. 2½% of net weight
(f) Distillate, per cent by weight to 210° C. calculated on extracted saturant.........		Max. 2
Distillate, per cent by weight to 235° C. calculated on extracted saturant.........		Max. 5
(g) Pliability at 77° F. (25° C.).............	At least four strips out of five shall not crack when bent thru 180° over a 1/16 in. mandrel	At least four strips out of five shall not crack when bent thru 180° over a 1/16 in. mandrel
(h) Saturant in moisture-free felt, by weight.	Min. 140%	Min. 140%

19. ASBESTOS FELT shall meet the following requirements:

DESATURATED

(a) Average thickness ....not less than 0.045 in.
(b) The relative proportion of the organic and asbestos fibers based on a microscopic count shall be:
Organic ....not more than 10%
Asbestos and hair ....not less than 90%
(c) The felt shall contain cattle hair uniformly distributed. The amount of cattle hair shall be from 10 to 15 per cent, by weight, of the asbestos fiber content.

SATURATED

(a) Width of roll................................32 to 36 in. ± ¼ in.
(b) Gross weight of roll.........................40–80 lb.
(c) Weight of material per 100 sq. ft. exclusive of wrapping and packing ....30 lb. ± 1½ lb.
(d) Loss on heating at 221° F. (105° C.) for 5 hrs...not more than 4%
(e) Moisture content ....not more than ½% of net weight
(f) Weight of saturant, not less than 55% of the weight of moisture free felt.
(g) Mullen test to show a strength of 45 lb. minimum and 55 lb. maximum at 70° F. (21° C.)

20. The surface of the felt shall be uniformly smooth and upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (i.e. stock which has not been beaten or shredded into fiber in the process of manufacture) and from particles of foreign substance (i.e. fragments of stone, metal, leather, rubber, straw, wood, etc.).

21. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2 in. strips at random across the entire sheet and splitting them open for their full length.

22. The finished cotton fabric or felt shall be free from visible defects such as holes, ragged or untrue edges, breaks, rents or cracks, and shall not be coated or covered with talc or any substance that will interfere with adhesion between the fabric or felt and the bitumen.

23. The saturated fabric shall be wound on mandrels not less than two inches in diameter and extending from two to four inches beyond the end of the roll. The rolls of saturated felt need not be wound on cores.

24. The rolls of cotton fabric or felt shall be securely wrapped or tied to prevent unrolling in transit and shall be capable of being unrolled easily at atmospheric temperatures above 50° F. without fabric sticking in such a manner as to injure it.

25. Cotton fabric, felt, asphalt and coal-tar pitch shall be delivered on the work in the original packages which shall bear the manufacturer's brand or label. The kind of material and purpose for which it is to be used shall be indicated.

26. INSULATING PAPER shall be a waterproof paper 36 inches wide and weighing not less than 10 lb. per 100 square feet.

27. PLASTIC CEMENT shall be composed of a semi-solid asphaltum, dissolved in a suitable volatile solvent and bodied up with a mineral filler consisting essentially of short-fiber asbestos.

28. The asphaltum forming the base of the plastic cement shall be either a fluxed native asphalt or a straight steam-refined asphaltic petroleum residual, the pure bitumen of which shall have a penetration at 77° F. (100 grams, 5 seconds) of not less than 30, and a ductility at 77° F. (5 centimeters per minute) of not less than 100 centimeters. The asphaltum shall be free from water, shall not have been subjected to oxidation or blowing, and shall contain no oxidized petroleums, residuals from the cracking process, sludge asphalts, tar or pitch products, or any admixtures or derivatives thereof.

29. The plastic cement shall comply with the following requirements:

Fluxed Native or Steam-Refined Petroleum Asphalt, not less than	38% by Weight
Short-fiber Asbestos, not less than	25% by Weight
Petroleum Solvent, not more than	25% by Weight

30. The plastic cement shall be of the proper consistency to spread readily with a trowel without drawing or pulling, or to be extruded through a suitable nozzle at the end of a flexible hose under a pressure of 50 lb. or more per square inch (such as can be obtained by a grease gun or in a compartment under air pressure).

31. When applied in a layer one-sixteenth (1/16) to one-eighth (⅛) of an inch in thickness, the cement shall set within twenty-four (24) hours to a tough plastic coating, free from blisters.

32. A patch of the cement one-sixteenth (1/16) to one-eighth (⅛) of an inch in thickness applied to the material upon which it is to be used, after drying for seventy-two (72) hours, on exposure to a temperature of 140° F. (60° C.) for five (5) hours shall not sag or slip more than one-quarter (¼) of an inch and shall not blister.

33. A patch of the cement one-sixteenth (1/16) to one-eighth (⅛) of an inch in thickness after drying for seventy-two (72) hours and after exposure to a temperature of 140° F. (60° C.) for five (5) hours shall be plastic and adhere well to saturated fabric, saturated felt, metal and concrete after exposure at 32° F. (0° C.) for one (1) hour.

34. A patch of the cement one-sixteenth (1/16) to one-eighth (⅛) of an inch in thickness after drying for twenty-four (24) hours and after exposure to a temperature of 140° F. (60° C.) for twenty-four (24) hours and cooling to 70° to 77° F. (21° to 25° C.) shall not crack or break from the roofing or metal when bent over a mandrel one (1) inch in diameter.

35. Asphalt Mastic shall be either premoulded blocks or poured-in-place mastic. Poured-in-place mastic shall be composed of (a) asphalt mixed with mineral aggregates, or (b) mastic cake mixed with asphalt and mineral aggregates.

36. Asphalt for Mastic shall be homogeneous and free from water. It shall meet the following requirements:

Penetration: at 77° F. (25° C.), 100 g., 5 sec.	25 to 30
Flash point (open cup)	not less than 347° F. (175° C.)
Loss on heating at 325° F. (163° C.), 50 g., 5 hr.	not more than 2 per cent
Penetration at 77° F. (25° C.), 100 g., 5 sec. of residue after heating at 325° F. (163° C.), as compared with penetration of asphalt before heating	not less than 60 per cent
Ductility at 77° F. (25° C.)	not less than 15 cm.
Proportion of bitumen soluble in carbon tetrachloride	not less than 99 per cent

NOTE: When less than 99 per cent of asphalt is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulphide) shall be reported.

37. Coarse Mineral Aggregate shall be well graded crushed stone or washed gravel, that will pass a ⅜-inch screen and be retained on a No. 10 screen. It shall be free from soft particles and organic matter.

38. Fine Mineral Aggregate shall be well graded washed sand or crushed stone, that will pass a No. 10 screen. It shall be free from soft particles and organic matter.

39. Mineral Filler shall be finely ground limestone or silica meeting the following requirements:

Passing a 200 mesh sieve....................not less than 50 per cent
Passing a 30 mesh sieve....................not less than 90 per cent

40. PORTLAND CEMENT shall meet the requirements of the standard Specifications for Portland Cement, of the American Railway Engineering Association, or current revisions thereof.

41. MASTIC CAKE shall contain from 14 to 18 per cent, by weight, of matter soluble in pure benzol. The soluble matter shall be asphalt which will meet the requirements of Section 35. The insoluble matter shall be granular mineral matter, which will meet the requirements of Sections 38 and 39.

42. PREMOULDED ASPHALT BLOCKS shall meet the following requirements:

They shall be 4 inches wide, 8 inches long, and 1¼ inches thick. A deviation of ¼ inch in length or ⅛ inch in width or thickness either way from these dimensions, shall be cause for rejection.

The blocks shall be formed in moulds, under a pressure of not less than 3300 pounds per square inch of surface. An absorption test shall be made on blocks dried for 24 hours at a temperature of 150° F. (65.5° C.) and then immersed in water seven days. The absorption of moisture under this test shall not exceed 1 per cent of the weight of the block.

43. ASPHALT PLANK shall be a mixture of asphalt, mineral matter and organic fiber (but free from wood fiber) and shall weigh not less than eighty-five pounds per cubic foot. The average of three tests shall meet the following requirements:

Asphalt (by Soxhlet extraction apparatus): Min. 40%; max. 48%; average 42.5%.
Mineral matter (measured as ash): between 35% and 45%.
Organic fiber, etc. (sum of asphalt and ash subtracted from 100): 8% to 22%.

The percentage of ash shall never exceed the percentage of asphalt.

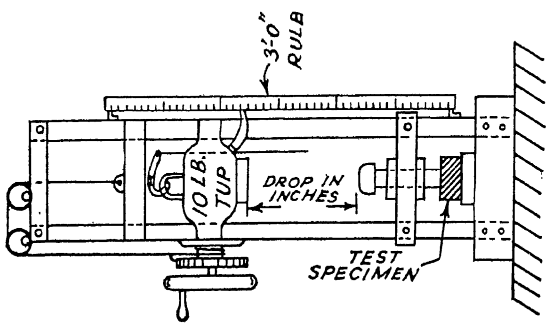
44. The finished plank shall pass penetration and impact tests described below.

45. The penetration test shall be made at room temperature in a Riehle Bros. penetrometer machine equipped to read to thousandths of an inch. A specimen 6 in. by 6 in. in size, after being submerged in water at 90° F. for not less than one hour, shall be placed upon a flat bearing plate forming a part of the testing instrument. The bearing plate, carrying the test specimen, is then elevated until contact is made between the top surface of the test specimen and the three ¾ in. balls. A load of 30 lb. is then applied for a period of ten seconds, reading is taken, and the load is immediately increased to 120 lb. and a second reading is taken one minute after the application of the 30 pound load. The 120 pound load is continued for a period of one more minute and a third reading is taken. The difference between the third and second readings shall not be greater than .013 of an inch.

46. The impact test shall be made at room temperature with a machine similar to the one shown below. Three specimens two inches in diameter, shall be cut from material to be tested, and submerged in water at 32° F. and held at this temperature for not less than two hours, after which one specimen shall be placed on a flat bearing plate, forming part of the testing machine, and on top of this specimen the one inch diameter pin will be placed to transmit the blow from the ten pound tup, falling at heights shown in the following table:

1st specimen—one blow falling 19 in. for plank 1¼ in. thick; 20 in. for plank 1½ in. thick
2nd specimen—one blow falling 21 in. for plank 1¼ in. thick; 22 in. for plank 1½ in. thick
3rd specimen—one blow falling 23 in. for plank 1¼ in. thick; 24 in. for plank 1½ in. thick

Two out of three specimens tested must stand the blow without being broken into pieces or showing a fracture or crack. Small cracks will be considered a failure.



Rough Sketch of Instrument for Making Impact Test.

47. The asphalt plank shall be of uniform width and thickness, have straight sides and all edges square. The thickness, width and length dimensions, and manner of bends, shall be as shown on plans. Curb and gutter plank shall be extruded, in final shape, from a mold. Curb, gutter and end plank which are bent shall be crated before shipment. All asphalt plank shall be so loaded at the factory that there will be no deformation caused by overhanging loads, etc., and if necessary, the load shall be blocked to prevent shifting while in transit.

48. Plank which does not meet the requirements of these specifications will be rejected and plank which shows an injurious defect subsequent to acceptance, will be rejected and shall be replaced by the manufacturer at his own expense.

49. Materials used in Concrete shall meet the requirements of the current specifications for concrete, of the American Railway Engineering Association. Reinforcing material shall be steel wire netting with a mesh not less than two inches. The wire shall be not smaller than No. 14 gage.

50. Brick shall be not less than 2¼ inches thick and shall be dense, hard burned, uniform in size and quality, free from warp and have square corners. The absorption of moisture by bricks immersed in water seven hours shall not exceed 10 per cent of the weight of the dry brick.

51. All materials shall be sampled and tested for the specified properties by the current methods recommended by the American Society for Testing Materials.

52. All materials to be furnished by a Contractor shall be delivered on the work at least three weeks before they are to be applied, in order that they may be tested and analyzed. No work shall be begun until the materials have been accepted by the Engineer.

Application

53. Membrane waterproofing shall not be applied in wet weather; nor when the atmospheric temperature is less than 50° F. without written permission from the Engineer. The waterproofing shall not be punctured and shall be free from pockets or folds.

54. Surfaces to be waterproofed shall be dry and clean, and any projection which might injure the membrane shall be removed. There shall be no depression or pocket in horizontal surfaces. Concrete shall be sufficiently cured before waterproofing is applied.

55. The waterproofing shall be turned without a break into drainage castings. Special care shall be taken to make the waterproofing effective along the sides and ends of girders and at stiffeners, gussets, etc. Grooves shall be filled with plastic cement specified in Sections 27 to 34 inclusive.

56. On surfaces that are vertical, or nearly so, the strips of cotton fabric or felt shall be laid vertical or with the slope; on other surfaces the strips shall be laid shingle fashion, beginning at the lowest part of the surface to be waterproofed. Sufficient cotton fabric or felt shall be allowed for suitable lap or anchorage at upper edge of surface to be waterproofed.

57. If specified by the Engineer, surfaces of concrete or steel coming in contact with asphalt waterproofing shall be given one coat of asphaltic primer (except where insulation is to be used at expansion joints) which shall be thoroughly worked in to give a uniform coating. The priming coat shall be applied approximately 24 hours before applying the waterproofing membrane and shall be dry before the first mopping of asphalt is applied.

58. The surface to be waterproofed shall be mopped with hot asphalt or coal-tar pitch (also referred to as bitumen), in sections, and immediately afterward a strip of cotton fabric or felt shall be laid on the mopping and pressed into place. The amount of bitumen used for each mopping shall be not less than 4½ gallons for each 100 square feet of surface.

59. Each mopping shall be so applied that it will completely cover and seal the cotton fabric or felt. Bitumen shall be frequently stirred and asphalt shall not be heated to a temperature above 350° F. or coal-tar pitch above 250° F. Kettles shall be equipped with armored thermometers.

60. For 2-ply work a section of the surface to be waterproofed 2 inches wider than a half width of cotton fabric or felt shall be mopped and on this hot mopping a half width of cotton fabric or felt shall be laid. The top surface of this cotton fabric or felt and an adjacent section of the surface to be waterproofed, having a total width of 2 inches greater than the full width of a strip of cotton fabric or felt, shall then be mopped and on it a full width of cotton fabric or felt shall be laid completely covering the first strip. Another full width of cotton fabric or felt shall then be applied in hot mopping, lapping the first strip not less than 2 inches. This process shall be continued until the entire surface to be waterproofed is covered, each succeeding layer of cotton fabric or felt to lap the next to last strip not less than 2 inches. Side laps shall be not less than 2 inches and end laps not less than 12 inches.

61. For 3-ply work the procedure shall be the same as for 2-ply work with the exception that the first strip laid shall be a ⅓ width of cotton fabric or felt; the second strip a ⅔ width of cotton fabric or felt and the third and succeeding strips, full widths of cotton fabric or felt; the second full strip to lap the first, or ⅓ width strip, at least 2 inches; each succeeding strip to lap the third preceding strip at least 2 inches.

62. If membrane waterproofing consisting of more than 3 plies is specified it shall be built up in shingle fashion similar to 3-ply work by addition of as many plies as required.

63. No patching shall be done without permission of the Engineer. Where patching is permitted for faulty waterproofing it shall extend at least 12 inches beyond the outermost faulty portion and the second and succeeding plies shall extend at least 3 inches beyond the preceding ply.

64. The work shall be so regulated that at the end of the day all fabric or felt that has been laid will have received the final coat of bitumen.

65. At construction joints a strip of insulated paper not less than 18 inches wide shall be placed between the dry surface which is to be waterproofed and the membrane waterproofing; this full width strip shall be placed before mopping for the membrane, omitting the primer.

66. Expansion joints shall be filled with plastic cement specified in paragraphs 27 to 34. Joints shall be dry and clean before being filled. They shall be slightly overfilled to allow for shrinking on drying.

67. THE PROTECTIVE COVER shall be placed as soon as practicable after membrane is laid. Dirt and other foreign material must be removed from the surface of the membrane immediately before the protective cover is placed. One of the following methods of protection shall be employed:

(a) A layer of poured-in-place asphalt mastic not less than 1¾ in. thick.
(b) A layer of asphalt blocks not less than 1¼ in. thick or a layer of asphalt plank not less than 1¼ in. thick, laid in an extra heavy mopping of asphalt, with joints filled with hot asphalt.
(c) A layer of adequately reinforced cement mortar or concrete not less than 2 in. thick.
(d) A course of hard burned brick not less than 2¼ in. thick with joints filled with hot asphalt except that when laid as a vertical wall or on a steep slope, bricks shall be laid in cement mortar.

NOTE: Mastic shall not be used on surfaces steeper than 4½ vertical to 12 horizontal. A protective cover containing asphalt shall be placed on only a membrane in which the bitumen used is asphalt.

68. Poured-in-place mastic shall be laid on one thickness of insulating paper placed on the membrane and shall be made as specified in Sections 69 or 70.

69. The asphalt and mineral aggregates shall be mixed in the following proportions, which should be varied, within the specified limits, to give a mastic of the greatest density and stability:

Asphalt meeting requirements of section 36	9 to 12 per cent
Coarse mineral aggregate meeting requirements of section 37	33 to 40 per cent
Fine mineral aggregate meeting requirements of section 38	33 to 37 per cent
Portland cement or mineral filler meeting requirements of sections 40 and 39	15 to 19 per cent

70. Mastic cake, asphalt and mineral aggregates shall be mixed in approximately the following proportions which should be varied to give a mastic of the greatest density and stability:

Mastic cake meeting requirements of section 41	48 per cent
Asphalt cake meeting requirements of section 36	5 per cent
Coarse mineral aggregate meeting requirements of section 37	28 per cent
Fine mineral aggregate and cement or mineral filler meeting requirements of sections 38, 40 and 39	19 per cent

71. The asphalt and mastic cake shall be heated to a temperature not higher than 350° F. The aggregates shall be mixed and heated and then placed in the kettle of melted asphalt. The ingredients shall be mixed thoroughly with iron stirring rods until all pieces of the aggregates are covered by and incorporated in the asphalt, care being taken to prevent burning. After the mastic is mixed it shall be removed from the kettle and poured into place while hot. It shall be placed in layers not more than ¾ in. thick, the thickness of the layers to be gaged by wooden strips held in position by suitable weights. The layers shall break joints not less than 6 in. and shall be brought to the required thickness with wooden spreaders and floats. The top layer shall be finished to the required grade and to a smooth surface. As soon as the top layer of the mastic is finished, it shall be given a mopping of hot asphalt sanded to a walking surface while hot.

72. THE PREMOULDED BLOCK PROTECTION COURSE shall be laid over the entire membrane, except around drainage castings and other places shown on the plans. In such places poured-in-place mastic or concrete shall be used. The blocks shall be laid in hot asphalt and the joints shall be filled immediately with asphalt which shall meet the requirements of Section 36.

73. ASPHALT PLANK shall be laid in a mopping of 50 pounds of hot asphalt per 100 square feet of membrane applied over a small enough area at a time so planks will be introduced while asphalt is still hot. The edges and ends of plank shall be heavily coated with asphalt after the planks are laid so that as the successive planks are laid and brought as close as possible to those already laid the spaces between the planks will be completely filled with hot asphalt and a small amount of asphalt will be squeezed out at the tops of the joints. The successive planks shall be placed in such a manner that the movement of the plank necessary to squeeze joints full of hot asphalt, shall be as small as practicable. After all planks have been placed, any joint not completely closed shall be filled with hot asphalt.

74. CONCRETE PROTECTION COURSE shall be not less than 2 in. thick and reinforced as required by the plans. The concrete shall be of a consistency as dry as workability will permit and shall contain 1¾ barrels of cement per cubic yard of concrete.

75. Unless approved by the Engineer, traffic shall not be allowed to pass over until the concrete deposited last has had the equivalent of seven days of good curing.

76. BRICK PROTECTION COURSE shall be laid over the entire membrane, except around the drainage castings and other places shown on the plans. In such places concrete shall be used. The joints between bricks shall be filled immediately with hot bitumen of the kind used for saturant and mopping except that when in a vertical wall or on a steep slope the brick shall be laid in cement mortar.

REPORT OF COMMITTEE XV—IRON AND STEEL STRUCTURES

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S. M. Smith,
*P. B. Spencer,
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H. C. Tammen,
G. H. Tinker,
G. G. Thomas,
G. H. Trout,
F. E. Turneaure,
F. P. Turner,
R. A. Van Ness,
H. T. Welty,
W. M. Wilson,
Committee.

* Died March 26th, 1932.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(2) Track anchorage over bridges and similar structures (Appendix A). It is recommended that the conclusions in the report be approved for publication in the Manual.

(3) Fusion welding and gas cutting for steel structures (Appendix B). It is recommended that the report be received as information.

(12) Repainting of steel bridges, with special reference to the condition requiring repainting and the economical method of doing the work (Appendix C). It is recommended that the report be received as information.

(13) Bronzes for various purposes in connection with Iron and Steel Structures (Appendix D). It is recommended that the report be received as information.

Respectfully submitted,

The Committee on Iron and Steel Structures,
A. R. Wilson, *Chairman.*

Appendix A

(2) TRACK ANCHORAGE OVER BRIDGES AND SIMILAR STRUCTURES

W. S. Lacher, Chairman, Sub-Committee; C. H. Chapin, R. P. Davis, G. A. Haggander, S. Hardesty, J. B. Hunley, M. S. Ketchum, B. R. Leffler, H. S. Loeffler, P. B. Motley, G. A. Phillips, C. D. Purdon, C. S. Sheldon, C. E. Sloan, G. H. Trout, R. A. Van Ness.

This Committee makes the following report and recommends that the conclusions be approved for publication in the Manual:

Prevailing practice in dealing with the longitudinal movement of rails on bridges was reviewed in the report of this Committee for 1931, Vol. 32, page 123. That report and the one presented here deal only with the open-deck bridges without movable spans.

Bulletin 351, November, 1932.

Ballast-deck bridges are believed to impose no problem not encountered in track on roadbed, while bridges embracing movable spans introduce problems of rail joints and anchorage that must be considered a special problem. The term anchorage as used in this report designates any means employed to resist the longitudinal movement or creeping of rails with respect to the structure.

As shown in the report cited above, there is a wide variation in both experience and opinion with respect to this problem. On some railways the use of any forms of anchorage against longitudinal movement of rails on bridges is expressly prohibited (except on structures embracing movable spans), cases being cited of serious injury to structures occasioned by their being subjected, through the agency of rail anchorage, to forces which they were not designed to resist. On other roads rail anchors are reported to have been employed on bridges with entire satisfaction.

This conflict of opinion and experience is to be expected. The magnitude of the forces that cause creeping of rails is not known and is obviously of so variable a nature that even if the range of the values of these forces were determined by experiment there would still remain the uncertainty as to the particular value to apply in any given case. Because of this uncertainty with respect to the forces to be resisted in anchoring track against creeping, rail anchors are applied to track on roadbed in accordance with empirical rules, increasing the number if the anchors originally applied prove inadequate.

Effort to cope with the longitudinal forces applied to track on bridges is a more serious matter since it not only involves the problem of the behavior of the track with respect to these forces but imposes also the disposition of the forces as they are applied by the track to the bridge. Progress in bridge engineering has reached a stage where the principal limitation on the attainment of maximum economy in design is uncertain as to the external forces to be applied during the life of the structure. To add to the unavoidable uncertainty with respect to future train loads; a further uncertainty in the form of longitudinal forces of unknown amount obviously leads to the waste attending empirical methods of design.

Much of the variable nature of forces of creeping track arises from the continuous character of track construction. As a consequence of this, there is no assurance that the rail anchors placed on a given stretch of track resist only the forces generated within the limits of that particular portion of the track. On the contrary, there is ample evidence to show that the anchorage applied to certain stretches of track may be compelled to resist the accumulated thrust generated in adjacent stretches and transmitted progressively from rail to rail. This phenomenon is of particular moment in the case of rail anchored on bridges because by its nature, rail anchorage on an open-deck bridge is more positive in action up to the point of failure than anchorage of track on roadbed, the effectiveness of which is necessarily limited to the resistance offered by the ballast to the movement of the ties. It is, therefore, readily possible that anchorage of rail on a bridge may transmit to the structure accumulated longitudinal forces generated in the track not only within the length of the bridge, but for considerable distances beyond its ends. This is the principal objection offered to the anchoring of rails on bridges by those who contend that the track should be restrained against longitudinal movement on the adjacent roadbed rather than on the bridge. Attention may be directed also to the fact that those who favor the holding of track against longitudinal movement on bridges impose the pre-requisite of adequate anchorage of the track on the adjacent roadbed.

In the opinion of this Committee there is not now available adequate data on the longitudinal forces which cause creeping of rails to warrant a definite recommendation with respect to the anchoring of rail on bridges. Such data could be obtained only through costly and protracted research. The Committee has, therefore, confined itself

to the following brief conclusions which apply to open-deck bridges not embracing movable spans.

Conclusions

1. Bridges are designed to resist only such longitudinal forces as are imposed within the length of the structure. The magnitude of the forces that cause rails to creep is unknown and may be transmitted from rail to rail for appreciable distances. Consequently the anchoring of rail on a bridge may impose longitudinal forces to the structure for which no adequate provision has been made in the design.

2. The first step in overcoming the creeping of rails on a bridge is to anchor the rails effectively on the adjacent embankment.

3. With adequate anchorage of rails on the adjacent embankment there should be no need for any anchorage of rails on short bridges.

4. If rails on a bridge creep in spite of effective anchoring of the rails on the adjacent embankments, the anchoring of the rails to the bridge will prove satisfactory and effective in many cases, but such anchoring must be undertaken only when the movement of rails on the bridge is not the result of uncontrolled creeping on the adjacent embankments.

5. If inability to control excessive creeping of the rails on the adjacent embankments produces objectionable movement of the rails on the bridge, it may be necessary to introduce adequately guarded switch points at each end of the bridge, anchoring the rails on the bridge if necessary, and allowing the rail on the adjacent embankments to run.

6. If inability to control excessive creeping of the rails on the bridge, in spite of effective anchorage of the rails on the adjacent embankments, produces objectionable movement of the rails on the bridge, it may be necessary to introduce adequately guarded switch points at each end of the bridge and allow the rails on the bridge to run.

7. In these cases where the rails are anchored on the bridges:

(a) Commercial rail anchors of demonstrated effectiveness on roadway track will generally be found effective on bridges.

(b) Rail anchors should be applied to ties that are effectively secured against longitudinal movement relative to the bridge members on which they are supported.

(c) Anchors applied to rails on a bridge should be so located relative to the expansion bearings of the spans, or slip joint as to permit the proper movement of the rails relative to the structure.

(d) The number of anchors applied and their distribution along the structure will depend on the severity of the creeping action, its direction and whether or not it is necessary to resist movement in more than one direction.

Appendix B

(3) FUSION WELDING AND GAS CUTTING FOR STEEL STRUCTURES

Albert Reichmann, Chairman, Sub-Committee; P. S. Baker, J. E. Bernhardt, A. J. Buhler, C. H. Chapin, R. P. Davis, F. O. Dufour, Thos. Earle, F. A. Howard, C. S. Heritage, Jonathan Jones, P. G. Lang, Jr., F. J. Pitcher, H. C. Tammen, G. H. Tinker, G. H. Trout, H. T. Welty.

This Committee presents as its report Tentative Specifications for Fusion Welding and Gas Cutting for Steel Structures, and recommends that they be received as information.

TENTATIVE SPECIFICATIONS FOR FUSION WELDING AND GAS CUTTING FOR STEEL STRUCTURES

Foreword

It is the intention of the Committee to establish a practice in the design, workmanship and inspection of fusion welding and gas cutting, covering such parts in bridge and building construction and repairs as designated by the Engineer.

The various publications of the American Welding Society were consulted and extracts used in writing these specifications. References for symbols, qualifications of welders, etc., are given to save repetition.

The various General Specifications of the American Railway Engineering Association, with additions and revisions, shall apply to these Welding Specifications except as provided otherwise herein.

Contents

(I) GENERAL APPLICATION

Fusion Welding

1. Fusion welding comprising arc and gas welding, when so designated, may be substituted for or used in combination with the riveting, bolting or other methods for connecting together or assembling the component parts of steel beams, girders, lintels, trusses, columns, and other structural steel used in buildings, railroad and highway bridge construction.

Gas Cutting

2. Gas cutting may be substituted for shearing or sawing in the fabrication of structural steel or for field alterations to existing steel.

(II) NOMENCLATURE, DEFINITIONS AND SYMBOLS

3. See Supplement on Nomenclature, Definitions and Symbols, American Welding Society Journal, November, 1929, and A.R.E.A. Bulletin, Vol. 32, No. 334, dated February, 1931.

(III) MATERIALS

Structural Steel

4. The grade of steel used shall conform to the requirements of the specifications of the structure welded.

Electrodes and Welding Rods

5. Electrodes and welding rods shall be made of commercially straight wire, either bare, fluxed or coated, of uniform homogeneous structure, free from irregularities in surface hardness, segregation, oxides, pipe, seams, or other harmful defects.

6. The diameter of electrodes and welding rods shall not vary more than plus or minus three per cent from diameter specified.

7. Electrodes and welding rods shall show good welding qualities in flat, vertical and overhead position and shall pass through the welding process without any unusual characteristics.

8. The surfaces of electrodes and welding rods shall be smooth and free from rust, oil and grease.

9. In the following tables of specifications for electrodes, the prefix letter E indicates that the material is intended for electric arc welding, and the prefix letter G indicates that the material is intended for gas welding.

10. The chemical composition of electrodes shall be within the following limits for uses specified.

LOW CARBON STEEL

E-No. 1B

Carbon	0.13–0.18%	Phosphorus	0.04% maximum
Manganese	0.40–0.60%	Sulphur	0.04% maximum
Silicon	0.06% maximum		

HIGH CARBON STEEL

E-No. 1C

Carbon	0.85–1.10%	Phosphorus	0.04% maximum
Manganese	0.30–0.60%	Sulphur	0.04% maximum
Silicon	0.02% maximum		

11. Electrodes shall be of the following sizes:

E-No. 1B—$\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{1}{4}$ inch dia.
E-No. 1C—$\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{7}{32}$, $\frac{1}{4}$, $\frac{9}{32}$, $\frac{5}{16}$ inch dia.

12. Grade E-No. 1B shall be used for welding mild steel, structural shapes, plates, bars or low carbon steel forgings and castings.

13. Grade E-No. 1C shall be used for welding high carbon steel and worn surfaces where great resistance to abrasive wear is desired and where machining is not necessary, such as rails, frogs, switch points, bearing surfaces, etc.

14. The chemical composition of the welding rods shall be within the following limits:

G-No. 1A

Carbon	not over 0.06 of one per cent
Manganese	not over 0.15 of one per cent
Phosphorus	not over 0.04 of one per cent
Sulphur	not over 0.04 of one per cent
Silicon	not over 0.08 of one per cent

15. The welding rods shall be of the following sizes: $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$ inch dia.

(IV) PERMISSIBLE UNIT STRESSES

Unit Stresses

16. Welded joints shall be proportioned so that the combined dead and live loads, and impact, if any, shall not cause the stresses therein to exceed the following amounts in pounds per square inch of net section through throat of weld excluding any reinforcement:

Shear on section through throat of weld	11,300
Tension on section through throat of weld	13,000
Compression on section through throat of weld	15,000

Fillet welds placed transversely to the direction of the principal stress shall be considered as under shear.

Working Stresses of Standard Fillet Welds in Shear

Size of fillet	*Pounds per linear inch*
1/4″	2,000
5/16″	2,500
3/8″	3,000
7/16″	3,500
1/2″	4,000
9/16″	4,500
5/8″	5,000

Bending

17. Maximum fiber stresses due to bending shall not exceed the values prescribed above for tension and compression respectively.

Combined Stresses

18. Stresses in welded joints due to wind when combined with other stresses, may exceed by 25 per cent the values prescribed in the table; provided, the section thus obtained is not less than that obtained if the wind force be neglected.

Eccentricity

19. In designing welded joints adequate provisions shall be made for bending stresses due to eccentricity, if any, in the disposition or section of base metal parts.

(V) DESIGN

Plate Girders

20. Girders shall be proportioned either by their moments of inertia or by the flange area method. In applying the flange area method to welded girders having no holes in the web, one-sixth of the web area may be considered a part of each flange area.

21. The web splices shall consist of plates, one on each side of the web.

22. Stiffeners may be either angles or flat bars, welded to the top and bottom flanges, and to the web, by continuous or intermittent fillet welds designed to transmit the stresses.

23. Connection of component parts of flanges to each other and of flanges to web shall be by continuous or intermittent fillet welds designed to transmit the stress.

24. In compression members composed of two or more plates fastened together, such as cover plates in a compression flange of a plate girder, plug or slot welds shall be used if the width between edge welds is more than 24 times the thickness of the thinnest plate in the direction perpendicular to the line of stress, and not more than 12 times the thickness of the thinnest plate in the line of stress. In tension members, plug or slot welds shall be spaced not more than 24 times the thickness of the thinnest outer

plate in either direction. The diameter of holes for plug welds and width for slot welds shall be greater than the thickness of material in which the holes or slots are placed.

Beams

25. The use of continuous beams and girders, designed in accordance with accepted engineering principles, shall be permitted provided that their welded connections be designed to transmit the stresses to which they may be subjected.

26. The connection at the end of non-continuous beams shall be designed so as to avoid excessive secondary stresses due to bending.

27. When the toe of a seat angle supporting a beam is to be welded to a web or to a column and is not truly formed, but is rounded due to worn rolls or other causes, either a preliminary fillet shall be deposited to fill the open space, or the rounded edge of the toe shall be sheared square, after which the full fillet required in the design shall be deposited to receive the full fillet required.

Trusses

28. In tension members connected by fillet welds the gross cross-sectional area shall be considered as resisting the stresses. If plug or slot welds are used, they shall be placed so as not to reduce gross sections, otherwise the effective net section shall be used.

29. For members having symmetrical cross-sections, the fillets shall be arranged symmetrically about the axis of the member or proper allowance shall be made for the unsymmetrical distribution.

30. For members of unsymmetrical cross-section, as angles, etc., the length of fillets shall be determined by taking moments about the gravity axis of the member.

Columns

31. The ends of columns shall be faced for bearing. Column splices, whenever practicable, shall consist of splice plates connected to the columns with proper amount of fillets. When sections of columns to be spliced are such that splice plates cannot be used, connections may be formed of plates and angles or other shapes designed to distribute the stresses properly. In all cases, column splices shall be so arranged that by bolts or other means the two sections of the columns to be spliced can be accurately aligned before welding and shall be of sufficient strength to carry the erection stresses.

32. Fillet welds connecting the component parts of a built-up column may be either continuous or intermittent; if intermittent, the length of each weld at the ends of the column shall be equal to the least width of the column. The length of the intervening welds shall be not less than four times the size of the fillet leg, spaced not more than four inches in the clear. The size, length, and spacing of the fillet welds shall be such as to provide the same strength, per unit of column length, as the rivets specified for riveted columns. If a member is in an exposed position, the joint between intermittent welds should be sealed against the entrance of water by a 1/8 inch fillet weld.

33. Lattice bars and tie plates, if used, shall be welded so as to secure strengths equal to rivets specified for riveted columns.

Welding

34. Main members subject to impact stresses shall have their welded connections designed for the sum of the Dead, Live aod Impact stresses plus an additional amount equal to 25% of the impact stress. Wherever practicable, welds subjected to impact should be parallel to the direction of the principal stress.

35. For welded structures, component parts of all columns, girders and trusses shall preferably be welded with fillet welds, but plug or slotted welds will be permitted if required to reinforce the fillet welds.

36. As far as possible, all joints shall be designed to eliminate overhead welding. All joints shall be arranged, as far as possible, so that the joints will be in shear or direct compression.

37. Tension butt welds shall not be used in main truss members, but may be used in secondary members, wind bracing connections, beam and girder connections.

Weld Dimensions

38. The size of a fillet weld shall be expressed in terms of the length of the side of the largest isosceles right triangle contained in the cross-section of the weld metal.

39. The size of a butt weld shall be expressed in terms of its net or unreinforced throat dimension.

40. The length of a weld shall be considered to be the unbroken length of the full cross-section of the weld. For fillet welds ¼ inch shall be added to the designed length to allow for the crater. No addition need be made for butt welds.

41. Fillet welds of lengths less than four times their size shall not be figured as part of any connection.

Butt Joint

42. One or both edges of base metal parts, ½ inch or more in thickness, transmitting stress by means of butt welds, shall be beveled. For single and double V joints, the bevel of each part shall be not less than 37½ degrees, thus forming an open space with an angle of not less than 75 degrees. For single and double bevel joints, the bevel shall be not less than 45 degrees.

43. In all single and double V and single and double bevel joints, the beveled edges shall have initial free distances of ⅛ to $\frac{3}{16}$ inches when welded with bare rods, and not to exceed $\frac{1}{16}$ inch when welded with coated rods. Steel ¼ and $\frac{5}{16}$ inches in thickness shall have welds laid with one bead; steel ⅜ and $\frac{7}{16}$ inches, two beads; steel ½ to ⅝ inches, three beads; steel ¾ to ⅞ inches, four beads; and steel 1 inch, six beads.

44. All butt welds shall be reinforced by depositing additional metal on the weld to a height extending beyond the surface of the thinnest part joined. The height of said reinforcement shall not be less than the following percentages of the thickness of the thinnest part joined:—20 per cent for single V and single bevel butt welds, and 12½ per cent, on each side, for double V and double bevel butt welds.

Lap Joints

45. Steel ¼ inch in thickness shall have fillet welds laid with one bead; steel $\frac{5}{16}$ to ⅝ inches, two beads; steel ¾ to ⅞, three beads; and steel 1 inch, four beads.

46. The contour of the cross-section of the fillet shall be as near as practicable to a triangle with equal sides, and with minimum side not less than the prescribed dimension of cross-section of fillet. The throat dimension shall be reinforced 20 per cent.

Number of Beads

47. The number of beads for butt and lap welds for different thicknesses of steel is shown in Fig. 1.

(VI) QUALIFICATIONS OF WELDERS

48. See Report of Structural Steel Welding Committee of the American Bureau of Welding, dated September, 1931.

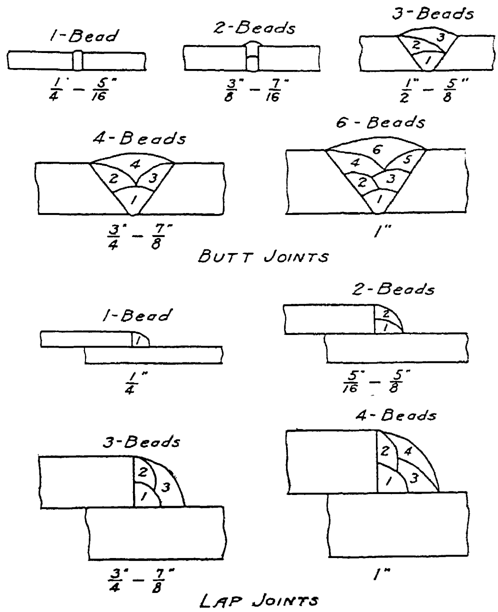


Fig 1

(VII) WORKMANSHIP

Welding Qualifications

49. Contractors for welding shall satisfy the Engineer that they can meet the qualification tests and furnish satisfactory materials and equipment to be used on the proposed **work.**

Welded Surfaces

50. Surfaces to be welded shall be free from loose mill scale, rust, paint, or other foreign matter. A thin coat of linseed oil or equivalent, over the surfaces to be welded, need not be removed. This provision applies both in the case of new structures and where new steel is to be welded to steel in an existing structure.

Assembling

51. In assembling and during welding, the component parts of a built-up member shall be held by sufficient clamps or other adequate means to hold the parts in proper relation for welding.

Quality of Welds

52. The weld metal shall be sound throughout and be free from excessive oxides, slag inclusion and gas pockets.

53. The weld metal shall penetrate into the root of the joint. See Fig. 2.

54. The weld metal shall be thoroughly fused with the base metal along all surfaces and edges of union. Uniform fusion with base metals of unequal thicknesses shall be obtained by playing the arc or flame a proportionately longer time upon the thicker material.

55. The surface of welds shall be reasonably smooth and uniform in contour. The depth of the crater at the terminus of weld shall not be less than $\frac{1}{16}$ inch.

56. The weld metal along the toe of the weld shall not overlap the base metal surface, but shall form an intimate contact therewith. See Fig. 3.

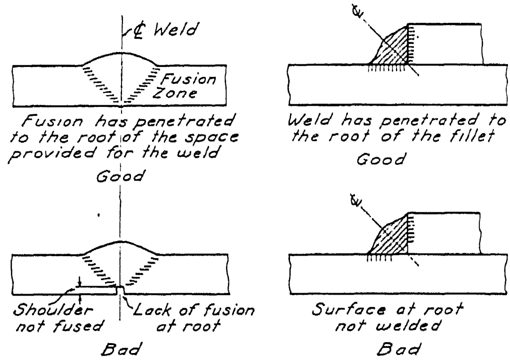


Fig. 2

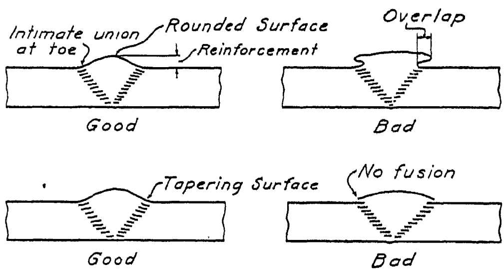


Fig. 3

57. The base metal along the toe of a weld shall not be reduced in thickness by the welding operation. See Fig. 4.

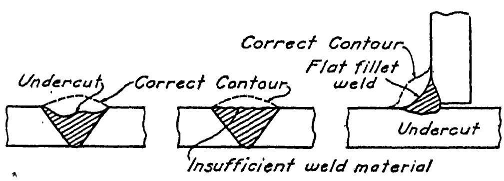


Fig 4

58. The arrangement of the joints to be welded shall be such as to enable the welder to have an unobstructed view of the surfaces to be welded during the welding operation.

59. When tack welds are located in the path of designed welds, they shall, during the welding operation, be either melted out or fused in with the final weld.

60. Proper fusion, penetration and soundness of weld shall be secured by using as short an arc as can be maintained for each form of weld.

61. In gas welding, unless otherwise specified, always use a neutral flame.

(VIII) PROTECTION OF STEEL

Shop-painted Structures

62. Structural steel parts shall not be painted before they are welded. On a structure specified to receive shop paint, parts that are welded in the shop shall receive the usual painting after the shop welding is finished. Parts to be field welded shall receive a coat of linseed oil after shop work is completed, and after erection and field welding, they shall receive the total number of coats specified for shop and field painting. Welding will be permitted on parts which have been coated with linseed oil without removing the oil.

Structures Not Painted in Shop

63. For structures not specified to receive shop paint, the parts to be welded in shop or field shall be cleaned of loose mill scale, rust or other foreign matter.

Encased in Concrete

64. No paint shall be applied to steel surfaces which are to be encased in concrete.

(IX) ERECTION

Temporary Supports

65. For all welded structures over 30 feet in height, erection bolts or equivalent means shall be employed for temporarily supporting the members.

Alinement

66. Proper alinement of the various members shall be made before connections are welded.

Safety of Welders

67. Adequate platforms or scaffolding shall be provided to permit favorable welding conditions and to insure the safety of the welders.

68. The operator, while welding, shall be protected from the rays by suitable equipment provided for the purpose.

(X) GAS CUTTING

Ability of Contractor

69. The contractor shall satisfy the Engineer as to his ability to produce satisfactory gas cuts.

Requirements

70. Gas cut edges shall be smooth and regular in contour.

71. Gas cutting may be used in the preparation of base metal parts for welding, provided the edges so cut are thoroughly cleaned after cutting to expose clean steel.

72. Gas cutting shall not be permitted as a substitute for milled surfaces.

73. Gas cutting shall not be permitted on any member while it is carrying stress. This restriction shall not apply to detail cutting for the correction of minor fabricating errors, where the removal of melted material resulting from such gas cutting would not reduce the required strength of the member if so cut.

74. Gas cutting of holes in a member which has not been designed therefor, shall not be permitted.

(XI) INSPECTION

Object

75. The object of inspection is to secure proper materials and workmanship in conformity with the plans and specifications.

Reference to Engineer

76. The inspectors must exercise generally their judgment in the interpretation of the plans and specifications and requirements for first-class workmanship. Doubtful matters shall be referred to the Engineer for his decision.

Qualifications of Welders

77. The inspectors shall ascertain if the welders are qualified to perform welding operations either in the form of a certified record of qualification tests issued by a reliable source or else by actually witnessing or supervising the performance of the prescribed qualification tests.

Presence of Inspectors

78. Satisfactory inspection of welding to secure first-class workmanship requires the presence of the inspectors in the shop and field during the actual welding operations. As far as possible, the inspectors shall observe the work of each welder sufficiently to satisfy themselves that the required standard of welding operation is maintained throughout the job.

Standard Gages

79. The gages standardized by the American Welding Society shall be used during inspection to determine if the proper amount of metal was deposited to make the size and length of weld specified. See Report of Structural Steel Welding Committee of the American Bureau of Welding, dated September, 1932.

Supervision of Arc Welding Operation

80. The inspectors should carefully observe the following:

(a) Cleanliness of the parent metal.

(b) Use of proper electrodes for welds specified.

(c) Position and motion of the electrode.

(d) The current used in welding is determined by the ammeter. This varies with the thickness of the material, size of the electrode, type of joint, and method of preparation.

(e) The arc voltage is determined by the voltmeter. This varies by the length of arc with a given current. A long arc causes improper fusion, lack of proper penetration, and a deposit of inferior oxidized metal. A long arc is easily recognized, not only by the higher voltage but also by the flame. A short arc throws a steady shower of small sparks, whereas, each of the explosions caused by a long arc scatters a considerable number of larger globules of metal. The use of the short arc results in the familiar crackling, snapping effect. If the arc is too long, explosions occurring at intervals of one-half second or more will result.

(f) The depth of penetration. This depends upon the length of the arc, amount of current and rate of travel. It may also be determined by the appearance of the arc crater and appearance of the work. The depth of the arc crater shall not be less than $\frac{1}{16}$ inch. When welding base metal of unequal thicknesses, uniform penetration is secured by playing the arc on the thicker material for a proportionally longer time.

(g) The quality of the weld. In good work, there is an intimate contact between the plate and the deposit, the junction between the two metals forming a concave surface. Even, smooth welds with clean and smooth surfaces are criterions of good workmanship. In poor work, there is an appreciable overlap. Overlap is usually caused by a long arc, too low a current, or too great a speed of travel. Poor welds have irregular pitted surfaces and are covered with a heavy coating of oxide.

Supervision of Gas Welding Operation

81. The inspectors should carefully observe the following:
   (a) Cleanliness of the parent metal.
   (b) Use of proper welding rods for welds specified.
   (c) Condition of flame.
   (d) Pre-heating of the parent metal.
   (e) Position and motion of welding rod and flame.
   (f) Depth of penetration into the root of the space provided for the weld.
   (g) Fusion of welding metal with parent metal.

Random Tests

82. In addition to the supervision of the actual welding, the inspectors shall verify the quality of the welding by random tests, such as chiseling the edges of the weld for penetration and fusion or by local remelting of the weld whereby holes, tunneling, improper fusion, insufficient penetration and other defects can be discovered. The procedure of inspection by remelting shall only be used if there is a doubt as to the quality of a particular weld or the work of an individual welder. Where remelting is used, care shall be used to rehabilitate the weld.

Index to Welding Specifications

Appendix C

(12) REPAINTING OF STEEL BRIDGES, WITH SPECIAL REFERENCE TO THE CONDITION REQUIRING REPAINTING AND ECONOMICAL METHOD OF DOING THE WORK

H. B. Stuart, Chairman, Sub-Committee; J. E. Bernhardt, C. S. Heritage, H. S. Loeffler, G. A. Phillips, F. J. Pitcher, C. D. Purdon, H. N. Rodenbaugh, C. S. Sheldon, I. L. Simmons, S. M. Smith, G. G. Thomas, G. H. Trout, R. A. Van Ness, H. T. Welty.

This Committee makes the following report and recommends that it be received as information:

Repainting

Conditions for repainting may be classified under the two following headings: "Desirable" and "Necessary".

Indications, when repainting is desirable, are:

(a) Appearances of rust spots and blisters.
(b) Curling up and chalking of the paint film.

Repainting is necessary upon the following indications:

(a) Large rusty areas with formation of rust scale.
(b) General disintegration of paint film.

Deterioration of Paint Film

The usual causes of deterioration of the paint film are:

(a) Ordinary weathering, such as rain, fog, sleet and salt bearing atmosphere.
(b) Direct sunlight on certain paint materials, such as asphalt.
(c) Concentrated locomotive smoke gases, such as in the case of bridges over railroad tracks.
(d) Gases from adjacent manufacturing plants.
(e) Brine drippings. This is one of the most severe exposures a paint film has to withstand.

Economical Methods of Repainting

(a) Cleaning.—Before repainting, the surface should be thoroughly cleaned. Where deterioration has reached an incipient stage, wire brushes, steel scrapers and scaling hammers, which may be pneumatically operated, should be used.

Where deterioration has reached an advanced stage, sand blasting is more effective and may be a more economical method.

(b) Spot Painting.—Where deterioration is evidenced by small rust spots or paint blisters, but with most of the paint film intact and in good condition after cleaning, such spots should be coated with priming paint. In the event of the season's program being extensive and sufficient force for complete repainting is not available, spot painting will usually protect the metal until the following season. Should complete repainting be deferred by spot painting, the surface should be again examined, and, if any rust spots have developed in the interval, these should be properly cleaned and primed before repainting.

(c) Complete Repainting.—One coat of priming paint should be applied to rusted areas, after cleaning, and to all areas where the old paint film has been removed in cleaning. After priming, one or more coats of finish paint should be applied to the entire surface. Under ordinary atmospheric conditions, one coat will be sufficient. For more severe exposures, two or more coats should be used. Where two or more coats are applied, they should be of distinctive shades to make certain that the entire surface of the structure is uniformly covered.

(d) Application.—Where the work is not extensive, generally speaking the most economical method of application is by hand. The paint should be well worked under the brush, and care taken to insure that all crevices and surfaces difficult to reach are covered.

Where the areas are large and continuous, spray painting may be an economical method of application, and is of advantage in reaching otherwise inaccessible surfaces. However, unless carefully carried out, spraying will involve cleaning of foreign surfaces, as well as the possibility of too heavy an application, resulting in sagging.

(e) Weather Conditions.—Painting should never be done when the surfaces are wet or frosty, during wet or freezing weather or when rain is imminent.

(f) Quality of Paint.—Only paints of good quality should be used as these are more economical in the end. Paints prepared with the pigment ground in oil are preferable to hand mixed paints prepared from similar materials. Proprietary paints of reputable make are, as a rule, preferable to specification paints, and are obtainable at practically no greater cost.

(g) Repainting by Company Force or Contract.—The data furnished the Committee as to the relative cost as between Company Forces and Contract work are not conclusive as to the more economical method, but it is felt that the repainting of large structures, or of a number of smaller ones within a restricted area, might be more advantageously done by contract, under close supervision.

Conclusions

1. It is better practice and more economical to do spot painting or complete repainting during the incipient stages of corrosion, rather than defer such work until corrosion has reached an advanced stage.

2. It is important that the surfaces to be repainted be thoroughly clean and dry, and that the weather and atmospheric conditions be favorable.

3. Only paints of good quality, thoroughly mixed, should be used.

4. On small jobs, it is preferable to employ Company Forces. In the case of large projects, contract work, under close supervision, may be more economical.

5. Paint gangs should be composed of men of experience, and be well equipped with all necessary apparatus.

Appendix D

(13) BRONZES FOR VARIOUS PURPOSES IN CONNECTION WITH IRON AND STEEL STRUCTURES

G. H. Tinker, Chairman, Sub-Committee; R. P. Davis, Acting Chairman; G. A. Haggander, S. Hardesty, O. E. Hovey, F. A. Howard, C. H. Mercer, I. L. Simmons, H. C. Tammen, R. A. Van Ness.

This Committee makes the following report and recommends that it be received as information.

THE COEFFICIENT OF FRICTION OF BEARING METALS FOR BRIDGE SEATS

By R. P. Davis and G. P. Boomsliter
West Virginia University—1932

Object of Investigation

The object of this investigation was to determine the coefficient of friction between various combinations of bronzes and steels. The West Virginia State Road Commission uses for expansion bearings in concrete girder bridges, cast phosphor bronze plates, meeting the specifications of the American Society for Testing Materials, designated as B22-21. Class B grade is used, the chemical requirements being as follows: Tin, not over 17 per cent, phosphorus, not over 1 per cent, other elements (except copper) not over 0.5 per cent, and the remainder copper. The compression strength requirements are as follows: Minimum deformation limit 18,000 lb. per sq. in., and a permanent set in 1 inch under 100,000 lb. per sq. in. between 0.10 and 0.20 inch.

In recent years many new alloys have been placed on the market, most of which are in the form of rolled bronzes. The tests given in this report were made by the Engineering Experiment Station of West Virginia University to determine the friction coefficients of some of these alloys as compared with those meeting the A.S.T.M. specifications. It was also desired to determine the coefficients of these various bronzes on rolled and cast steels.

Acknowledgments

The following companies furnished specimens for these tests: American Manganese Bronze Company, American Brass Company, Egyptian Iron Works, Fairmont Mining Machinery Company, and the Riverside Metal Company. The apparatus for making the tests was designed by Professor G. W. Grow, of the Department of Machine Design and Construction, and built in the University shops. The 50-ton hydraulic jack used in developing the lateral force was loaned by the State Road Commission.

Materials Tested

Table No. 1 gives a list of the materials tested and the names of the companies furnishing the same. Table No. 2 gives the chemical composition of the different bronzes, their strength properties, Brinell hardness numbers and specific gravities. These figures were in some cases furnished by the manufacturers, and in other cases were determined from coupons sent with the specimens.

The rolled steel was taken from local stock and was of structural grade. The cast steel was ordered to meet the specifications of the American Society for Testing Materials, designated as A27-24, Class B, medium.

TABLE NO. 1 - MATERIALS TESTED

Specimen Number	Material	Trade Name	Furnished By	Remarks
(1)	Cast Bronze	Hy-ten-sl #4	Amer.Mang.Bronze Co.	Machined surface. Push parallel to grain
(1a)	Cast Bronze	Hy-ten-sl #4	Amer.Mang.Bronze Co.	Machined surface.Push at right angle to grain
(2)	Rolled Bronze	#30, 4" Hard	Riverside Metal Co.	Surface as rolled.
(3)	Cast Bronze		Egyptian Iron Works	Planished surface.
(4)	Rolled Bronze	Hy-ten-sl #1	Amer.Mang.Bronze Co.	Surface as rolled.
(5)	Rolled Bronze	1/4" Pls., 4# Hard, Anaconda grade A, Phosphor bronze. 1" Pls., 2# Hard, Anaconda grade D, Phosphor bronze.	American Brass Co.	Surface as rolled.
(6)	Rolled Bronze	Tobin Bronze	American Brass Co.	Surface as rolled.
(7)	Rolled Bronze	Class A	American Brass Co.	Surface as rolled.
(8)	Rolled Bronze	Class B	American Brass Co.	Surface as rolled.
(9)	Rolled Bronze	Leaded phosphor bronze	Amer.Mang.Bronze Co.	Surface as rolled.
(10)	Rolled Bronze	Aluminum Bronze	Amer.Mang.Bronze Co.	Surface as rolled.
(11)	Rolled Bronze	No. 330	Riverside Metal Co.	Surface as rolled.
(12)	Rolled Bronze	No. 31	Riverside Metal Co.	Surface as rolled.
(13)	Rolled Bronze	No. 47	Riverside Metal Co.	Surface as rolled.
(15)	Rolled Steel		Open market	Surface as rolled.
(16)	Rolled Steel		Open market	Ground surface.
(17)	Cast Steel		Fair.Mining Mach.Co.	Machined surface.Push parallel to grain.
(18)	Cast Steel		Fair.Mining Mach.Co.	Machined surface.Push at right angles to grain.

TABLE NO. 2 - PROPERTIES OF BEARING METALS

SPECIMEN NUMBER	CHEMICAL COMPOSITION - PER CENT						STRENGTH PROPERTIES						
							Tension		Compression				
	Copper	Tin	Zinc	Lead	Phos.	Others	Prop. Limit #/sq.in.	Ult. Strength #/sq.in.	Deform Limit #/sq.in.	Deform at 100,000 #/sq.in.	Ult. Strength #/sq.in.	B.H. No.	Sp. Gr.
(1) (1a)	64-68	23-27				Remainder	60,000	116,800		0.10 at 121,500	141,800	229	7.79
(2)	95.5	4.3			0.2					0.10		176	8.9
(3)	81.5	17			1.0	0.5				0.125 @ 90,000		121	8.4
(4)	64-68	23-27				Remainder	25,000	89,300	70,000	0.20 @ 143,100	143,100	156	7.89
(5)#	95 90	5 10			Trace				62,000 73,000	.072 .058		165	8.92
(6)#	60.93 59.50	0.65 0.58	38.38 39.87	.01 .03		Iron 0.03 Iron 0.02	62,200 41,500	71,400 63,700	54,000 22,000	.126 .174		118	8.4
(7)#	89.44	10.34			0.03				45,000 37,000	.130 .180		134	9.02
(8)#	89.44	10.34			0.03				53,000 68,000	.075 .072		183	9.0
(9)	80	10		10			18,500	43,200		.232		76	8.66
(10)#	89					Alum. 10 Iron 10	18,500	74,450		.144		118	7.64
(11)	95.46	4.22			.306					.093		183	9.03
(12)	93.85	4.84		1.09	.199					.0935		192	8.97
(13)	91.68	8.18			.111					.03		217	9.0
(15-16)												149	
(17-18)							50,000	86,000				143	

#Upper column for 1/4" plates. Lower column for 1" plates.

Method of Testing

The apparatus used in carrying out these experiments is shown in Fig. 1. The blocks "BB" were centered between the heads of the 400,000 lb. Olsen Universal Testing Machine. One of the friction plates "a" was placed on the lower block "B", the other on the bottom of the upper block "B", while a third friction plate "b" was placed between the other two. The plates "a" rested against projecting shoulders of the blocks "B". P indicates a normal load from the testing machine which was distributed over approximately 9 sq. in. of test specimen area. In most cases the plates "a" were ¼ in. thick and the plate "b" was 1 in. thick.

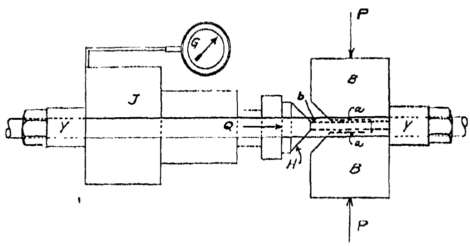


FIG. 1.—Sketch of Apparatus for Friction Tests on Bearing Metals.

The horizontal force Q was produced by a 50-ton hydraulic jack, "J", placed horizontally. The base of this hydraulic jack, as well as the back face of the blocks "B", took bearing against 4-in. square steel bars. Two 2-inch round threaded rods passed through the ends of these bars to form the yoke "Y". The push was transmitted from the head of the jack to the plate "b" by means of the head "H". The horizontal pressure was read by means of a gage "G" which was previously calibrated in the testing machine. Two gages were used; a high pressure gage for pressures above 2500 lb. per sq. in. and a low pressure gage for pressures of 2500 lb. per sq. in. and less.

Friction values were determined for normal pressures of from 500 to 2500 lb. per sq. in. in 500 lb. increments, and for normal pressures of from 5000 to 20,000 lb. per sq. in. in 5000 lb. increments. In running a test the normal load was first applied and then the pump on the jack was operated until slipping occurred, when the gage reading was observed and recorded. Readings at the higher pressures were not quite as accurate as those at the lower ranges because of leakage in the jack.

Tests were first made on five bronzes, one cast steel and one rolled steel. These tests indicated that the coefficient of friction was practically independent of the normal pressure. For this reason, in the later tests pressures up to 3000 lb. per sq. in. only, were used, thereby giving six friction observations for each run, as compared with nine observations for the first runs. A total of 113 combinations of metals were tested.

In most cases friction readings were taken with increasing loads, check readings being taken as the loading was reduced. In case of serious discrepancy between the two sets of readings, the work was repeated.

Results of Tests

Plates 1 to 5 inclusive, give typical curves showing the relation between the coefficient of friction and the normal intensity of pressure. Although this coefficient varies quite markedly in some cases, it seems to be independent of the intensity of pressure.

On Plate 6 there is shown graphically all test results. For each test there is given the average coefficient, for all loads, the minimum and maximum values. The results are

given in the order of ascending average results. Where the average values are the same the plotting has been in the order of the ascending minimum values.

On Plates 7 to 14 inclusive, are given the same results as on Plate 6, but arranged differently. Here the results of each material sliding on all other materials are grouped together.

On Plate 15 is given the averages of all tests for each class of material. The values given as maximum were found by averaging all maxima of the material in question when sliding on all other materials with which it was tested, as shown in Plates 7 to 14, inclusive. The values noted as average and minimum were found in a similar manner.

Effect of Plane Marks

The only specimens with planed surfaces were (1), (1a), (17) and (18). The first two are bronzes and the second two cast steel. Specimens (1) and (17) were so planed that the push was parallel to the direction of planing, while specimens (1a) and (18) had the push at right angles to the planing marks. The planing of both bronze and steel was fine.

In general the planed bronze surfaces showed up very well, as will be seen on Plate 15, where (1a) gave the lowest average coefficient of all the tests, namely, 0.13, while (1) showed an average value of 0.138. Very little difference is seen whether the grain is parallel to the direction of push or perpendicular to it; or whether the pieces are so placed that the grain of one is perpendicular to the grain of the other.

Effect of Ground Surfaces on Rolled Steel

It will be noted that rolled steel behaves much better when the surface is ground smooth than when used as rolled, probably due to the effect of removing the mill scale.

Coefficients of Friction by Means of Inclined Planes

Certain selected tests were made to determine the coefficient of friction by the use of inclined planes. One end of a board was hinged to a table and a short cleat nailed transversely across it. One plate was placed against the cleat and another laid upon it. A measured horizontal distance was laid off on the table from the hinged end of the board, and at this point a vertical scale was placed. The free end of the board was then slowly lifted until the upper plate slipped on the lower one and then the vertical scale was read. This vertical distance divided by the horizontal distance gives the coefficient of friction. The results, each of which is the average of three or more observations, are given in Table No. 3. It will be noted that these coefficients are higher than those obtained by the other method and also that they range between wider limits.

Conclusions

(1) The coefficient of friction is independent of the normal pressure.

(2) The range in coefficients expressed in terms of the average of pressure intensities varying from 500 to 20,000 lb. per sq. in., is from about 0.10 to 0.245, 85 per cent of the values being within the limits of 0.12 and 0.165.

(3) Machined surfaces give as low coefficients as rolled planished surfaces.

(4) Grinding the surface of rolled steel plates when mill scale is present, materially reduces the coefficient of friction.

(5) The average coefficient of bronze on steel was 0.146, which is also the value of the average of all tests. The general average of steel on steel was 0.181.

(6) The coefficient of friction as determined by the use of inclined planes is materially higher than found by the pressure method.

TABLE NO. 3
COEFFICIENT OF FRICTION USING INCLINED PLANE

(15) Structural Steel	on same (15)	0.48	
" "	" Bronze #1 (1)	0.20	
" "	" " #2 (2)	0.375	
" "	" " #3 (3)	0.285	
" "	" " #4 (4)	0.235	
" "	" " #5 (5)	0.37	
" "	" Cast Steel (18)	0.27	Grain perpendicular to movement.
(1) Bronze #1	" Bronze #1 (1)	0.169	
" "	" " #2 (2)	0.22	
" "	" " #3 (3)	0.18	
" "	" " #4 (4)	0.20	
" "	" " #5 (5)	0.19	
" "	" Cast Steel (18)	0.164	Grain perpendicular to movement.
" "	" Cast Steel (17)	0.186	Grain parallel to movement.
(2) Bronze #2	" Bronze #2 (2)	0.36	
" "	" " #3 (3)	0.25	
" "	" " #4 (4)	0.26	
" "	" " #5 (5)	0.33	
" "	" Cast Steel (18)	0.20	Grain perpendicular to movement.
" "	" Cast Steel (17)	0.236	Grain parallel to movement.
(3) Bronze #3	" Bronze #3 (3)	0.31	
" "	" " #4 (4)	0.33	
" "	" " #5 (5)	0.34	
" "	" Cast Steel (18)	0.28	Grain perpendicular to movement.
" "	" Cast Steel (17)	0.225	Grain parallel to movement.
(4) Bronze #4	" Bronze #4 (4)	0.29	
" "	" " #5 (5)	0.243	
" "	" Cast Steel (18)	0.182	Grain perpendicular to movement
" "	" Cast Steel (17)	0.19	Grain parallel to movement.
(5) Bronze #5	" Bronze #5 (5)	0.40	
" "	" Cast Steel (18)	0.30	Grain perpendicular to movement.
" "	" Cast Steel (17)	0.25	Grain parallel to movement.
(18) Cast Steel	" Cast Steel (18)	0.28	Grain perpendicular to movement.
(17) " "	" Cast Steel (17)	0.195	Grain parallel to movement.
(17) " "	" Cast Steel (18)	0.24	Grain perpendicular to each other.

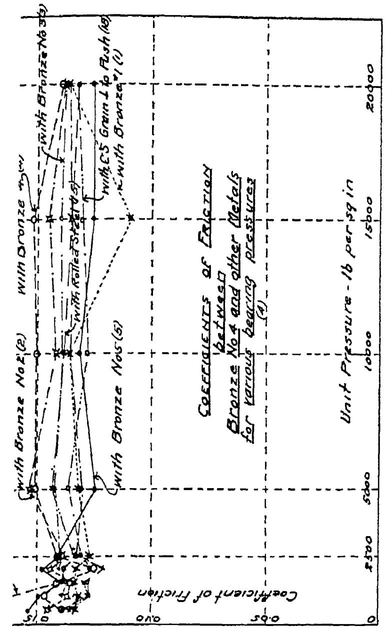
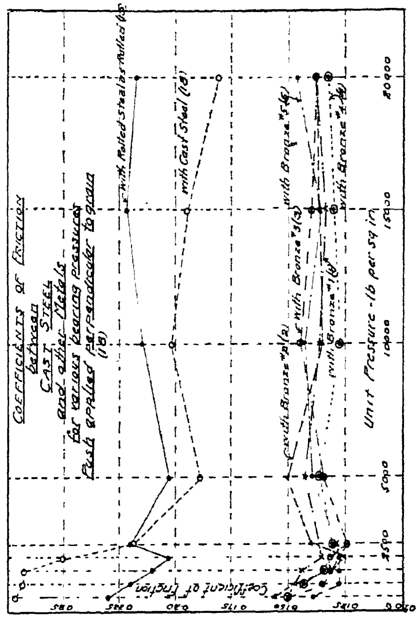


PLATE 2.a



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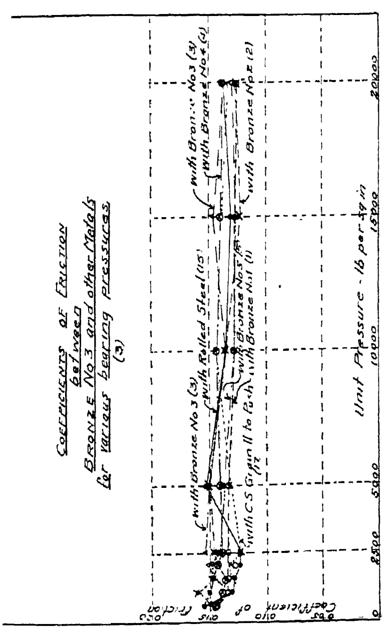

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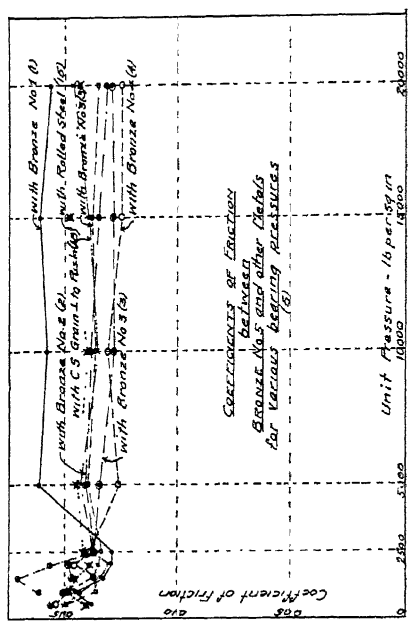

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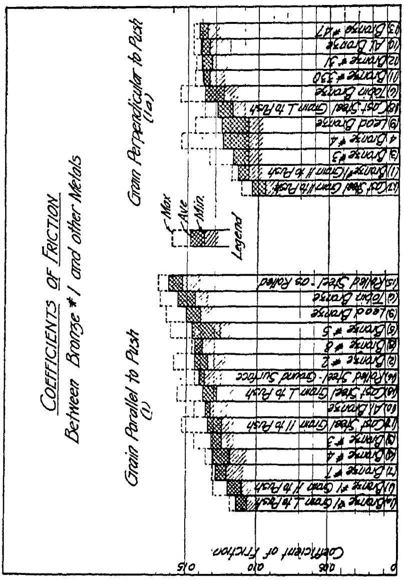

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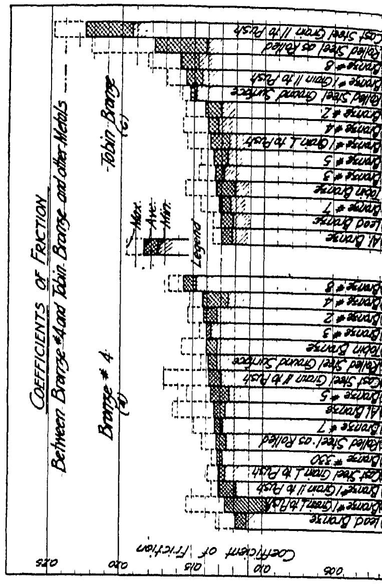

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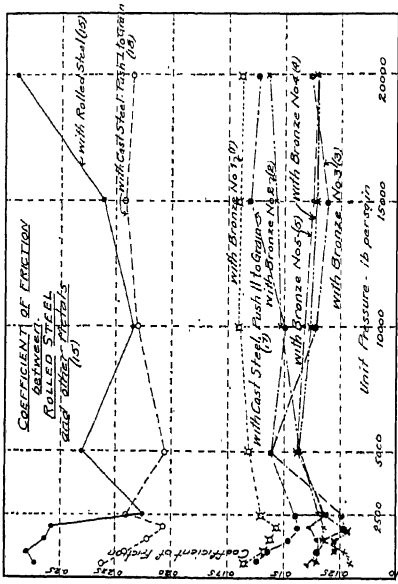

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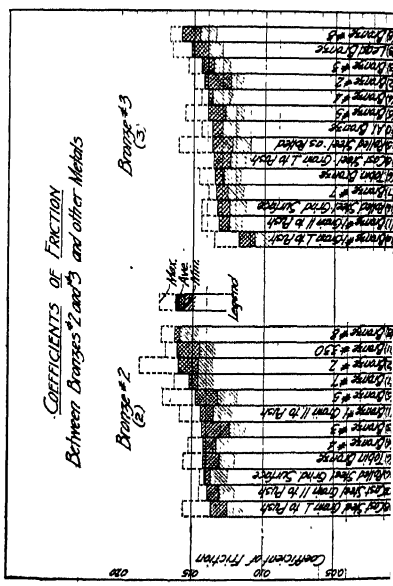

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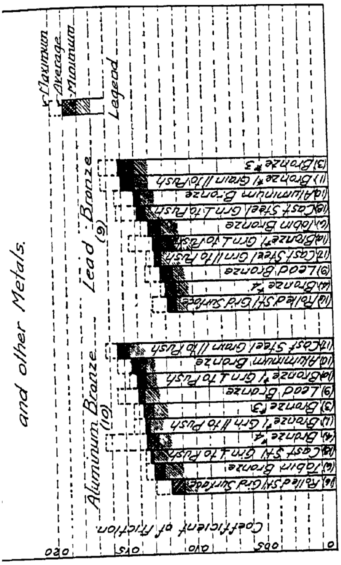

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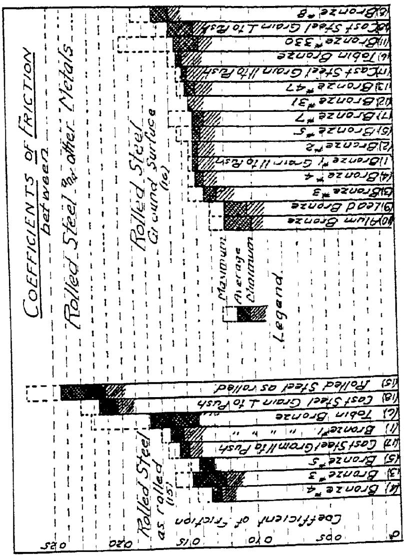

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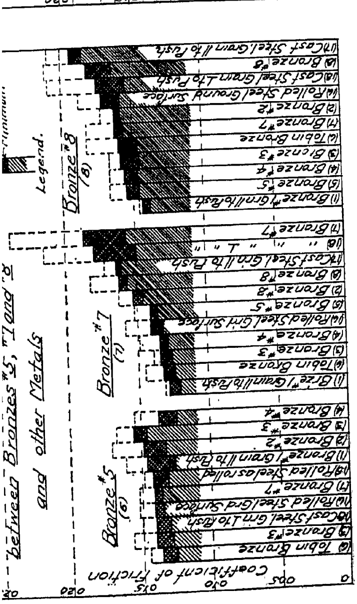

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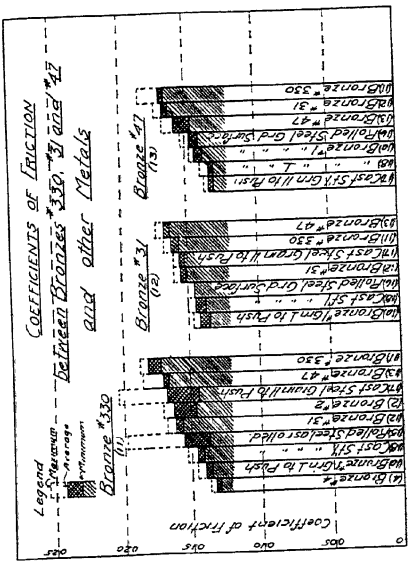

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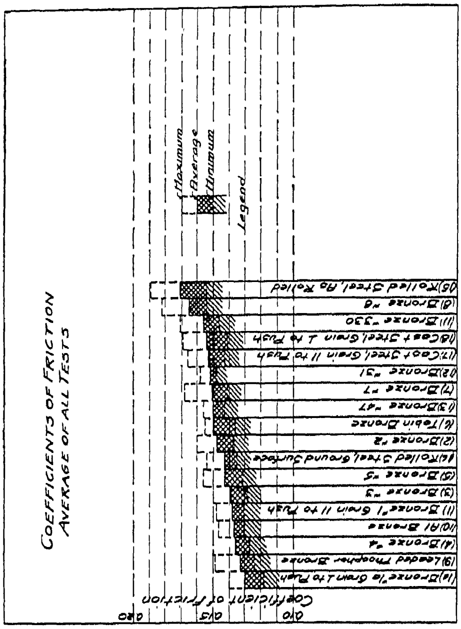

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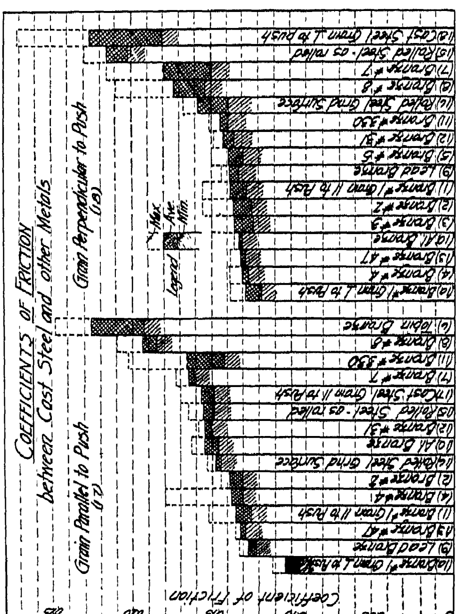

PLATE 14.

REPORT OF COMMITTEE XXVI—STANDARDIZATION

J. C. Irwin, *Chairman;*
Louis Yager, *Vice-Chairman;*
J. R. W. Ambrose, *Vice-Chairman;*
H. Austill,
C. W. Baldridge,
R. C. Bardwell,
E. H. Barnhart,
F. L. C. Bond,
J. G. Brennan,
W. J. Burton,
A. P. Crosley,
Robert H. Ford,
P. M. Gault,
*E. A. Hadley,
C. C. Haire,
C. R. Harding,
M. Hirschthal,
L. P. Kimball,
C. R. Knowles,
J. A. Lahmer,
F. R. Layng,
F. L. Nicholson,
H. L. Ripley,
F. C. Shepherd,
A. L. Sparks,
Earl Stimson,
J. E. Teal,
F. M. Thomson,
W. M. Vandersluis,
A. R. Wilson,
Committee.

* Died, November 11, 1932.

To the American Railway Engineering Association:

Your Committee respectfully presents its report on the following assignments:

1. Encourage the use of A.R.E.A. recommended practices and consider subjects for recommendation to the Board of Direction for sponsoring as projects for National Standardization.

2. Maintain contact with Standardization bodies and keep the Association informed on important matters developed by such contact.

In regard to the extension of the use of A.R.E.A. Recommended Practices, this Committee directs attention to its report of last year, Vol. 33 of the Proceedings, pages 149 and 150, in which it refers to the value of the material in the Manual, which has been developed by the combination of the time and skill of many men most experienced in the various subjects.

The Recommended Practices should establish themselves through their intrinsic merit, but if members of the Association neglect to use them, it sometimes may be due to their lack of realization of the value of uniformity in general practice. As has been pointed out in previous reports of this Committee, uniformity is of the greatest importance in matters which involve relations between railways and other interests and between two or more railways, they, in turn having similar relations with other railways. (See Vol. 32 of Proceedings, page 113, on the relative importance of uniform practices).

This Committee has not issued questionnaires to determine the extent of the use of the Manual, because it is doubtful whether such questionnaires are helpful in extending its use. Moreover they would be expensive and, if distributed widely enough to secure information with reference to the extent of use of the Recommended Practices of all committees, the returns would be so voluminous that it would be impracticable to publish them. They would consist of information only, which probably would not lead to any greater use of the Manual. In the past, when comprehensive questionnaires have been sent out, a customary reply has been that the Manual is always referred to and its Recommended Practices used in part. This constitutes use of the Manual but it may not be the maximum desirable.

An indication of the recognition given the work of the A.R.E.A. by interests outside of its membership is the fact that the National Directory of Specifications for 1932 issued by the Bureau of Standards, U.S. Department of Commerce, contains one hundred and forty-eight references to A.R.E.A. Recommended Practices.

About nineteen hundred copies of the 1929 Manual have been distributed.

Bulletin 351, November, 1932.

Members of the Association are here requested to give to the chairmen of committees their views as to the importance of uniform practice in any matters which, in their opinion, are likely to cause trouble or expense if practices vary on different railways. The chairmen of committees can bring up such matters for consideration by this Committee, with a view to further action toward the securing of the general acceptance of the Recommended Practice concerned. Subjects deserving special attention are those in which uniform practice will effect material economy and those in which uniform practice will avoid disturbances in the relations between the railways and shippers, manufacturers of supplies, contractors and the public.

Members of the Association can also aid in the extension of uniform practice by seeing that the various departments of their railway other than Construction and Maintenance are impressed with the value of the Manual and, if possible, see that they are supplied with it or at least refer to it in connection with all matters on which this Association has taken action and has approved for the Manual. On some railways, all departments make use of the Manual in cases where it applies, on others it is thought to be useful only to the Engineering Department, often through lack of knowledge of what is in it and the caretaking processes through which it has been developed. The extent of its use depends largely on the training of general officers, the course through which they have risen to their executive positions and their willingness to keep informed as to what others are doing and profit by it. The difference in the organization of railways, especially in the relation between operation and maintenance and construction is likely to affect the attitude of the officers toward the work of the A.R.E.A.

In the use of Recommended Practices for materials, the Purchases and Stores Department is most deeply interested. In matters concerning Standardization and Simplification it is important that close co-operation be maintained between the work of Division VI—Purchases and Stores, A.R.A., and the A.R.E.A., functioning also as Division IV—Engineering, Construction and Maintenance Section.

It may not be generally known that the forms of agreement prepared by Committee XX—Uniform General Contract Forms, and approved by the Association, have had the benefit of legal advice from many quarters during their development and that the forms used in relations between the railways and shippers have been developed with the collaboration of the American Railway Development Association representing the industrial departments and also, to a considerable extent, with committees representing large shippers. This is just one example of the thoroughness of the procedure of the committees of the A.R.E.A., which no one railway could duplicate by itself.

If, in the experience of any member of the Association, a situation develops which indicates that, in order to secure more general use of a Recommended Practice, it should be revised, the member should call the situation to the attention of the chairman of the committee concerned so that the points involved may be considered in connection with revision of the Manual.

AMERICAN STANDARDS ASSOCIATION (ASA)

For the benefit of members of the Association who have not come in direct contact with the American Standards Association, the following outline of its organization and purposes is quoted from the Standards Year Book of the U.S. Department of Commerce for 1932.

> "The American Standards Association (ASA) is the recognized medium through which American industry functions in setting up for itself nationally acceptable standards. In essence it is a federation of 45 national technical societies, trade asso-

ciations, and Federal Government departments, and it brings together all those directly concerned with a project, to study a problem, to formulate a workable and acceptable standard, and submit it for approval to an authorized committee, so that when this committee (made up of individuals officially appointed by the organizations concerned with the subject) has given its approval, there is assurance that the standard represents a real national opinion and may be considered an 'American Standard' in the broadest sense.

"At present more than 2,500 officially accredited representatives from every branch of industry, representing approximately 600 national organizations, are participating actively in the association's work. In December, 1930, the United States Government Printing Office became one of the member bodies of the ASA.

"The administration of ASA affairs is vested in a board of directors of nationally known industrial executives. The final approval of standards rests with the Standards Council, which is made up of representatives of all 45 member bodies, all of which are organizations or groups of organizations having an important interest in standardization. The council, therefore, acts as a court of review in which the work of technical committees is either accepted or rejected with reasons. The approval of a standard by the ASA means that everyone concerned has had an opportunity to participate in the work, that the work has been carried out under a procedure that has been regular, open, and above-board, and that the standard represents a real national agreement on what is best in American engineering and industrial practice at the time of approval.

"The association's offices are at 29 West Thirty-ninth Street, New York, N. Y. Dr. P. G. Agnew is the Secretary, and a technical staff, including engineers who have had practical experience, assists in carrying on the work. The actual setting up of standards is done by technical committees representing the producing, distributing and consuming groups concerned with the projects. It is a basic requirement of ASA procedure that no standards shall be approved unless all important interests have been represented in developing them, thus avoiding the domination of any one interest except when the consent of other groups has been granted.

"The productive, initiating power of the ASA lies largely in the work of the technical committees, and a brief review of the procedure which must be followed will indicate why their recommendations may be rightfully considered as a real national agreement. Any responsible group may request the initiation of a standardization project. The request is usually accompanied by a statement setting forth the desirability of the particular project and the benefits that would accrue from national approval of a standard on the subject. The ASA then calls a general conference of all interests concerned with the subject in hand to decide whether or not the work shall be launched and what method is to be followed. In the majority of cases a 'sectional committee' is charged with the task of making a study and presenting a final recommendation on the subject. Sometimes the committee may set about its work autonomously, or it may function under the support and guidance of one or more of the organizations chiefly concerned (officially called the 'sponsor'). Any organization having an interest in the project has a right to appoint representatives on the committee, and it is one of the important functions of the ASA to see that all groups having an interest in a project are invited to appoint representatives on the technical committee. It is not unusual for conflicting interests to clarify their differences in committee discussions and to arrive at a practical compromise in making progress possible. Before a project developed by a committee can become an approved American Standard, the great preponderance of committee opinion must first be favorable.

"In addition to the sectional committee method, which is most commonly followed, the association procedure includes three other methods: Existing standard method, proprietary method, and general acceptance method. Under the first of these three, provision is made for the approval of existing standards when it has been shown by proper exhibits of the submitting body that the standard represents a true consensus of competent industrial opinion with respect to its suitability for national adoption. Proprietary standards, or standards developed and sponsored by a body having an outstanding and controlling interest and importance in the field of the standard, may be approved by the ASA when it is shown that the standard has the unanimous agreement of those who are concerned with its development and use. The general acceptance method is especially applicable in simple cases not

requiring protracted technical consideration. The procedure which applies here requires that a conference be called of those primarily concerned—producers, consumers, and other competent interests—and if the decision of the conference is authenticated and supported by a sufficiently large number of written acceptances of the conference's recommendation from those who are concerned with the scope and provisions of the recommendation, then this is considered sufficient for approval as an American Standard.

"Nationally acceptable standards have been prepared under the auspices of the ASA in practically every major field of industrial activity or are now under way. In addition to providing a suitable medium for the establishment of nationally acceptable standards, the ASA serves as a clearing house for information on standardization work both in the United States and abroad. It also acts as the authoritative channel in international cooperation in standardization activities."

The Chairman of this Committee is the Representative of Division IV—Engineering, A.R.A., on the Standards Council of the ASA and, in this capacity maintains contact between the ASA and the Construction and Maintenance Section (A.R.E.A.), the Electrical Section and the Signal Section of the A.R.A.

Sidney Withington, member and former Chairman of Committee XVIII—Electricity, and Representative of the New York, New Haven and Hartford Railroad in the Electrical Section, A.R.A., is the Representative of the A.R.A. on the Electrical Standards Committee (E.S.C.) of the ASA, which serves as a central standardizing committee in the field of the electrical industry. Its recommendations are acted upon by the Standards Council of the ASA before adoption as American Standards.

Mr. Withington is also a member of the United States National Committee of the International Electrotechnical Commission.

C. R. Harte, member A.R.E.A., is Chairman of the Electrical Standards Committee though not as a designated representative of the A.R.A.

Meeting of this Committee with Representatives of the American Standards Association

Last year this Committee reported on its meeting with representatives of the National Bureau of Standards and the Federal Specifications Board in Washington, D. C. This year, in order to further extend its contacts with national standardizing bodies, it held a meeting at the rooms of the American Society of Civil Engineers, New York City, May 20th, 1932, with a program including addresses by members of the staff of the American Standards Association and by a representative of the American Institute of Weights and Measures. H. J. Forster, Secretary of the A.R.A., made a statement on the progress of the adoption of A.R.A. Recommended Standards for Railroad Highway Grade Crossing Protection.

This meeting was attended by President J. V. Neubert, H. J. Forster, twenty members of this Committee or their representatives and six members of the staff of the ASA; twenty-eight in all.

Members of the ASA staff spoke on its activities as follows:

Dr. P. G. Agnew, Secretary—Organization and working methods of the ASA, its relations with Member Bodies and other standardizing organizations.
John Gaillard, Mechanical Engineer—Tolerances, methods of gaging and methods of showing tolerances on drawings.
Cyril Ainsworth, Assistant Secretary—Safety Codes.
H. M. Lawrence, Mining Engineer—Mining standards and material specifications.

L. D. Burlingame, of the Brown and Sharpe Manufacturing Company, representing the American Institute of Weights and Measures, spoke of the status of the English and metric systems of weights and measures and laid emphasis on the general use of the English system in American industry.

At this meeting, this Committee considered several subjects which had been proposed as projects for which national standardization is desirable.

It was agreed that the status of subjects as outlined in a following section of this report should be investigated and suitable steps taken to advance them toward national standardization, or, where projects already are under way, to indicate to the organizations or committees which have them in charge, the interest of this Committee in their advancement to American Standards.

A.R.A. Representation in A.S.A.

The representation of the A.R.A. on the Board of Directors and on the Standards Council of the ASA remains the same as reported last year.

The list of ASA projects showing the Sectional Committee members from the A.R.A., printed in full last year in Vol. 32 of the Proceedings, remains the same except for the projects, including new ones, for which the complete revised A.R.A. personnel is listed below.

	A.S.A. Project	*A.R.A. Div. or Sec. Represented A.R.E.A. (Const. & Maint. Sec.) Committee Contact*	*Members representing Railway Associations*
B1	Screw Threads, Standardization and Unification of	IV Eng.—Com. V—Track —Sig. Sec. V Mech.	J. V. Neubert H. G. Morgan H. E. Smith W. I. Cantley F. M. Waring Alt.—S. S. Riegal
B3	Ball and Roller Bearings	V Mech.	W. I. Cantley F. M. Waring Alt.—S. S. Riegal
B4	Cylindrical Parts and Metal Gages, Allowances and Tolerances for	V Mech.	W. I. Cantley Alt.—S. S. Riegal
B18	Bolt, Nut and Rivet Proportions	A.R.A.—Rail Com. IV Eng.—Com. V—Track —Com. XV—Iron and Steel Structures V Mech.	Lem Adams J. V. Neubert Alt.—J. B. Myers P. G. Lang, Jr. Alt.—O. E. Selby J. McMullen, C. B. Smith
B27	Plain and Lock Washers letter P eliminated—no change in personnel		
B32P	Wire and Sheet Metal Gages	IV Eng.—Sig. Sec. I Oper.—T. & T. Sec.	H. G. Morgan R. F. Finley
C8	Wires and Cables, Insulated (Other than Telephone and Telegraph), Specifications for	IV Eng.—Elec. Sec.	C. B. Martin
C16	Radio	I Oper.—T. & T. Sec.	A. R. Belmont
C29	Insulators for Electric Power Lines—Letter P eliminated	IV Eng.—Sig. Sec. —Elec. Sec. I Oper.—T. & T. Sec.	G. W. Chappell G. I. Wright R. F. Finley
C35P	Railway Motors	IV Eng.—Com. XVIII—Electricity —Elec. Sec.	H. A. Currie Alt.—J. V. B. Duer T. E. Sharpley Alt.—Sidney Withington
C37P	Power Switchgear	IV Eng.—Elec. Sec.	J. S. Hagan
C44—1931	Rolled Threads for Screw Shells of Electric Sockets for Lamp Bases, Specifications for, Year added to designation of Project — no change in personnel		

	A.S.A. Project	A.R.A. Div. or Sec. Represented A.R.E.A. (Const. & Maint. Sec.) Committee Contact	Members representing Railway Associations
E8—1926;	E9—1926; E10—1929		
E11—1926	Designs for Girder Rails completed, Sec. Committees discharged		
M26P	Clean Bituminous Coal, Specifications for	VI Pur. & Stores	C. E. Smith
Z10	Scientific and Engineering Symbols and Abbreviations	IV Eng.—Sig. Sec. —Const. & Maint. Sec. I Oper.—T. & T. Sec.	E. K. Post Alt.—J. V. B. Duer A. H. Johnson
Z23	Sieves for Testing Purposes	IV Eng.—Com. VIII—Masonry	Meyer Hirschthal

Inch–Millimeter Conversion for Industrial Use (A.S.A. B48)

At a general conference held in New York City, October 21st, 1932, under the auspices of the ASA, attended by representatives of manufacturers' association, the U.S. Bureau of Standards, U.S. Navy Department, engineering societies and other standardizing agencies, it was unanimously agreed to recommend the adoption of the value 25.4 as the American Standard inch-millimeter ratio for industrial use.

This conference had been arranged as a result of the Ford Motor Company having requested the ASA, in March 1932, to make arrangements for having industry in this country consider the adoption of an American Standard specifying the use of the value 25.4 as the conversion factor between inch and millimeter values for industrial use.

In 1926 the adoption of this conversion factor was recommended by an international conference held in New York in which representatives of eighteen national standardizing bodies, including the British, took part. However, at that time there had been no request from American industry to take action on the matter and it was not brought up as an ASA project until this year.

As a result of the recent conference, conversion tables will be prepared under the auspices of the ASA with a view to their adoption as American Standard under ASA procedure. They are required especially by American industries dealing with countries using the metric system.

The American Standards Association has always maintained a strictly neutral attitude in regard to the English and the metric systems of weights and measures. Standards submitted for ASA approval may have dimensions either in inches or millimeters. However, an overwhelming majority of American Standards are expressed in English units. The ball bearing standard was first worked out in millimeters and is accepted on the metric basis as an international standard. Some standards involving scientific measurements also are on the metric basis. In some standards the values are given in both the English and metric units.

The American Railway Association is opposed to the mandatory adoption of the Metric System in this country. It has a Joint Committee on the Metric System held in readiness for any conferences on the subject. W. D. Faucette, Chairman of this Joint Committee, represents the A.R.A. on the Council of the American Institute of Weights and Measures.

USE AND CITATION OF AMERICAN STANDARDS (ASA)

This Committee desires to direct attention to the importance of the use of ASA Standards and reference to them in reports and Recommended Practices in place of similar standards of any Member Body of the ASA which may have been used or referred to before the standard had been adopted as American Standard under ASA procedure.

The American Railway Association is one of the forty-five industrial, technical and Federal organizations or departments working together as Member Bodies of the ASA.

for the study of projects for national standardization, the adoption as American Standards of such standards of Member Bodies as may be found suitable and, through the work of sectional committees, the preparation of new standards which will be of value to American industry where no suitable standards exist. Numerous other Member Bodies have created standards which have been generally accepted prior to the adoption of such standards by the ASA. Conspicuous among these are the American Society for Testing Materials (A.S.T.M.), the Society of Automotive Engineers (S.A.E.), the U.S. Bureau of Standards, the Federal Specifications Board and other government departments.

Organizations having a standard which appears to be suitable for adoption as American Standard present it for consideration in the ASA and act as its sponsor. A standard which has been adopted by the ASA has the highest status that any standard can have in American industry.

The American Railway Association is still appropriating $15,000 a year in aid of this work in the ASA and, besides having a member on the Board of Directors and three Representatives and five Alternates on the Standards Council of the ASA, it has 77 men assigned to 102 memberships on 50 Sectional Committees working on ASA projects, appointed from Divisions or Sections of the A.R.A. who are especially well qualified to handle their respective subjects and exert their influence in the committee-work which leads to standards.

With this recognition by the A.R.A. of the work of the ASA the importance of the use of the results of this work is apparent. References to ASA Standards applies to the Revision of the Manual as well as to new work of committees.

The ASA publishes, semi-annually, a list of adopted Standards showing prices at which they can be secured. Arrangements have been made for each Committee of the A.R.E.A. to have one free copy of any American Standard required in its committee-work, except in cases where a standard is still published by a Member Body which originated it and a charge is made to the ASA for it. In connection with mechanical dimensions, there is a Tentative American Standard for "Tolerances, Allowances and Gages for Metal Fits", ASA B4a—1925, a pamphlet of twenty-four pages which sells for 50 cents.

Price lists of American Standards may be secured from the American Standards Association, 29 West 39th Street, New York, N. Y. As the ASA has been in operation only a few years, it has made only a fair beginning. However, it has adopted 227 standards and now has about 400 projects under investigation. Its Year Book and bulletins are furnished to the chairmen of all A.R.E.A. committees.

SUBJECTS RECOMMENDED FOR NATIONAL STANDARDIZATION

As a result of inquiry in regard to subjects most desirable to advance to national standardization, special investigation has been made by this Committee of the status of the following subjects:

Specifications for Creosote for Wood Preservation.
Specifications for Trolley Wire and Messenger Wire.
Wire and Sheet Metal Gages.
Grading Rules and Dimensions of Lumber.

The situation on these subjects was found to be as follows:

Specifications for Creosote for Wood Preservation

Research work leading to standardization and methods of test has been in progress through a joint committee of the A.R.E.A., the American Society for Testing Materials and the American Wood Preservers' Association.

At the meeting of Committee XVII—Wood Preservation, October 18th, 1932, Chairman F. C. Shepherd, who is also a member of the A.W.P.A., brought up, for consideration, the question of the advancement of Specifications for Creosote as an ASA project. It was agreed that the work of the Joint Committee of the A.R.E.A., A.S.T.M. and A.W.P.A. should first be completed. After this shall have been done, one or more of these organizations can act as sponsor for the project for recommendation to the ASA for adoption as American Standard. If the A.R.E.A. should sponsor the project, the procedure would first have to be approved by its Board of Direction.

Trolley Wire and Messenger Wire

Specifications for trolley wire have been developed by a joint committee representing the A.R.A., A.E.R.A. (A.T.A.), and A.S.T.M. The specifications cover two types, one being for Round and Grooved Hard Drawn Copper Trolley Wire and the other for Round and Grooved Bronze Trolley Wire. They have been approved by the A.S.T.M. and by the A.R.A.—Electrical Section, and will be sponsored as an A.S.A. project by one or both of these organizations.

Specifications for messenger wire and other items of overhead trolley line material involve varied manufacturing interests according to their character and will be handled separately. No report on their status can be made at this time.

The ASA Year Book lists Project C 43—Overhead Trolley Line Material, Standards for (Standardization proposed) but it is reported by the ASA that the organization for this work has never been set up.

This Committee will indicate its interest in seeing that progress be made on these subjects.

Wire and Sheet Metal Gages

The ASA has a project under way listed as B32P—Wire and Sheet Metal Gages, this being sponsored by the American Society of Mechanical Engineers (A.S.M.E.) and the Society of Automotive Engineers (S.A.E.). The A.R.A. has two members on the Sectional Committee; H. G. Morgan, representing Division IV—Engineering, Signal Section, and R. F. Finley, representing Division I—Operating, Telegraph and Telephone Section.

The scope of this project covers the standardization of a method of designating the diameter of metal and metal alloy wire, the thickness of metals and metal alloys in sheet, plate and strip form and wall thickness of tubing, piping and casing made of these materials; and the establishment of a standard series, or standard series, of nominal sizes and of tolerances for wires, sheets and strips.

It is reported by the ASA that there has been no recent activity on the part of the Sectional Committee on this project. It is understood that the committee will start by working on the designation of wire diameters and sheet metal thicknesses in decimal fractions of an inch as a preliminary step toward the establishment of a simplified standard series of wire diameters and sheet thicknesses with corresponding tolerances in place of the present confusing situation with gage numbers meaning different things, resulting from the practices that have grown up from the use of several different systems of gages. Even though such standardization may be difficult of accomplishment and may involve sacrifices and the overcoming of individual prejudices built up on practices of long standing, it is apparent that, eventually, it must be accomplished for the general good. This Committee has taken steps to indicate its view that American Standards for wire and sheet metal gages should be adopted and it will urge that progress be made on this project.

Grading Rules and Dimensions of Lumber

The ASA has no project under way covering this subject.

This Committee has under investigation, through its own members, and through other members of the Association in contact with lumber committees, the status of the various phases of the subject being handled by national lumber standardizing organizations and by groups interested in a specific kind of lumber or a geographic territory, with the purpose of showing its interest in progress toward national standardization in various lines. Consumers are familiar with the confusion arising from diverse practices. Their interests must eventually be served by national standardization and the application of the principles of simplified practice.

Substantial progress has been made by co-operation of various associations of producers and consumers, and the A.R.E.A., through Committee VII—Wooden Bridges and Trestles, has had an important part in this work. The results are printed in the Manual. A current assignment of that Committee covers "Simplification of grading rules and classification of timber for railway uses".

The Central Committee on Lumber Standards with headquarters in Washington, D. C., consists of eleven representatives of lumber manufacturers, wholesalers, retailers and consumers. Associated with it are the Consulting Committee on Lumber Standards and the Hardwood Consulting Committee. In cooperation with the U.S. Departments of Agriculture and Commerce, this Committee makes recommendations for the simplification of sizes, grades, nomenclature and trade practices in the lumber industry. The Committee's findings are published as "American lumber standards" by the Division of Simplified Practice, U.S. Bureau of Standards.

Attention is directed to articles which appeared in Commercial Standards Monthly (U.S. Bureau of Standards) during this year as follows: April 1932—Grade Marked Lumber Activities Renewed by Lumbermen—Annual Meeting of Northeastern Retail Lumbermen's Association; May 1932—Significance of Grade Marking of Lumber in Boston—City of Boston Building Code revised to require grade marking of all lumber; July 1932, page 9—Lumbermen of Canada and New Hampshire adopt Grade Marking of Lumber, and page 17, New Grading Rules adopted by Hardwood Lumbermen—paper delivered by L. S. Beale at meeting of National Association of Purchasing Agents.

The progress made by these associations and committees is recognized, but in order to hold the gains already made and cover the activities of more independent groups, it appears that procedure under the organization of the ASA is most desirable. This Committee will continue its investigations.

STATUS OF A.R.A. RECOMMENDED STANDARDS FOR RAILROAD HIGHWAY GRADE CROSSING PROTECTION

and to coordinate the activities of the railroads in conforming to the principles adopted, and to provide a medium by which public authorities can be acquainted with the most modern thought of the railroads in these matters".

Frank Ringer, former Director and Chairman of Committee IX—Grade Crossings, is Chairman of this Joint Committee on Grade Crossing Protection, A.R.A. He authorizes the following statement from that committee, on progress in securing adoption of uniform methods of protection:

"The Joint Committee on Grade Crossing Protection is in contact, through individual effort of its members, with the Railroad and Highway Commissions of the various states, as well as national organizations interested in the problem. Invitation has been accepted for the full committee to attend the annual convention of the National Association of Railroad and Utilities Commissioners this fall, at which time it is expected to call attention to the committee's efforts for securing adoption of uniform methods of protection. It is also expected to secure the approval of Bulletin No. 1 by the Executive Committee of the National Conference on Street and Highway Safety, and of the Joint Committee on Signs, Signals and Markings of the National Conference and American Association of State Highway Officials.

"Replies received to a questionnaire sent out recently to the Executive heads of all Class I carriers indicate a very decided trend toward the increasing use of the recommended standards, and in general it may be said the progress made is very encouraging from the standpoint of all parties interested.

"Our records show that by Commission order the states of Colorado, New York and Rhode Island require signs or signals conforming to A.R.A. recommended practice. The state of Michigan has passed a law requiring the installation of crossbuck signs and flashing light signals substantially in accord, with the addition of reflector buttons to all auxiliary signs and the letters of the crossbuck. The Public Utilities Commission of New Jersey has signified its approval of the signs and signals as illustrated in Joint Committee Bulletin No. 1, and the present practice of several states, as a result of Commission Order, is substantially in accord with A.R.A. recommended practice.

"Formal adoption of A.R.A. standards is being given serious consideration by several state commissions, although nothing definite can be reported at this time. In addition, it is an open question in various other states, where the railroads are allowed to install such signs and signals as they desire. This is aiding to some extent in the use of uniform protection throughout the country."

Joint Committee on Grade Crossing Protection, A.R.A.
October 8, 1932.

* * *

A.R.A. Bulletin No. 1, to which reference is made, carries the title "Railroad Highway Grade Crossing Protection—Recommended Standards".

SIMPLIFIED PRACTICE

Simplified Practice is a branch of Standardization because, by the process of elimination, it reduces the number of types, sizes and grades of material to be standardized.

Revisions and additions to the Manual for 1932 published in Bulletin 347 contains valuable material on Simplification adopted by the Association at its 1932 Convention, as a result of recommendations presented by Committee VII—Wooden Bridges and Trestles. A.R.A. Division VI—Purchases and Stores, has a Committee on Standardization and Simplification of Stores Stocks, with which committees of the A.R.E.A. handling similar subjects should maintain contact.

The Division of Simplified Practice, U.S. Bureau of Standards, calls attention to the quite general use of the simplified invoice and other commercial forms published in S.P.R. No. 37-28, and the interest of the General Committee of Division VI—Purchases and Stores, in a program for simplified lines in catalogs, price lists and other trade literature.

The Division of Simplified Practice also reports that there are now 140 simplified practice recommendations in effect and that approximately 11,000 different organizations in the United States, including many railways, have accepted one or more of them. The list of effective Simplified Practice Recommendations is issued quarterly by the U.S. Bureau of Standards and may be had on application.

S.P.R. No. 17–31, Forged Tools, issued January 4th, 1932, includes A.R.E.A. Track Tools as adopted for the Manual in 1930. In this simplified practice recommendation, the variety of forged tool items has been reduced from 665 to 431 and the eye sizes from 120 to 11.

CANADIAN ENGINEERING STANDARDS ASSOCIATION (C.E.S.A.)

A. F. Stewart who has been a representative of the Canadian National Railways on the Main Committee of the Association has retired from the Committee and C. B. Brown, member, A.R.E.A., Chief Engineer, Operating Department, C.N.R., Montreal, has been appointed to succeed him. Otherwise the railway personnel on the Main Committee remains as reported last year.

B. Stuart McKenzie, Secretary, has written the following statement on C.E.S.A. 1932 activities for this report.

> Activities during the past year have been confined to work under the direction of the Sectional Committees on Civil Engineering and Construction, Mechanical Engineering and Electrical Engineering, and will be reported under these three heads.

Civil Engineering and Construction

Consideration has been given for some time to the preparation of a specification for Wood Piles and Pile Driving, which will include information on the best methods of preservative treatment of timber. A most important feature of the specification will be information on the available sizes of timber for piling purposes which is being compiled in cooperation with the Forest Products Laboratories of Canada.

At the request of the Royal Architectural Institute of Canada, a committee on Building Materials has been organized, under which it is proposed to organize several panels dealing with specific projects. The first question which will be considered is that dealing with standard Brick Sizes, and it is hoped to have a conference before the end of the year. This subject has been under discussion for some time and a standard was practically agreed upon some two or three years ago, but owing to misunderstanding it was impossible to secure adherence thereto. It is proposed to consider Lumber, Mill Work, Steel Work, Fireproofing Materials, and other products used in the construction industry.

Mechanical Engineering

The most active work in this field has been in connection with Screw Products. A revised edition of a standard for Machine Screws and Nuts has just been issued, following the publication of a standard list for Cap Screws, Set Screws, Studs and Nuts. It is hoped also to issue shortly a standard for Machine, Carriage and Plow Bolts and Nuts.

Another standard which it is expected will prove of great service is that covering Blade Punching for Road Grading Machinery. The adoption of this standard will allow for interchangeability of cutting blades and mould boards on road graders, and it has been unanimously approved by all the highway departments in Canada and by the leading manufacturers of road grading machinery.

A committee is now being organized to consider the preparation of a uniform Safety Code for Passenger and Freight Elevators, for use in Canada, and the cooperation of government authorities in the different provinces, manufacturers, and insurance interests, is being obtained for the purpose of studying this problem.

Electrical Work

The year has been marked by the adoption of the Canadian Electrical Code in the Province of Manitoba. The entire nine provinces of Canada have now adopted the Canadian Electrical Code, which provides for uniform electrical regulations in connection with interior wiring throughout Canada, and a tremendous improvement has been noted in the standard of electrical installations during the last few years. Part I of the Code only covers inside wiring, but Part II covers approval specifications for electrical apparatus. These specifications outline the conditions which must be observed before electrical apparatus of any kind can be sold or otherwise used in Canada. The first specification, covering Power-operated Radio Devices, was issued during the year, and specifications for Electrical Signs and Electrical Equipment for Oil-burning Apparatus will shortly be issued. Consideration is also being given to Enclosed Switches, Service-entrance and Branch Circuit Breakers, Electric Clocks, Portable Electrical Displays and Incandescent Lamp Signs, Electrical Capacitors (Condensers), Electrical Fixtures, Electrical Floor Scrubbing and Polishing Machines, and Fractional Horsepower Motors.

Tests made by the Hydro-Electric Power Commission Laboratory at Toronto are now being generally accepted throughout Canada by the different inspection authorities, this being provided for under "Approved" as defined in the Canadian Electrical Code.

Revision of the specification covering Watthour Meters, and a new specification for Demand Meters is now under consideration, also a specification for Power Transformers and for Transformer and Switch Oil. It is also proposed to consider standards for Magnet Wire and Oil Circuit-breakers, and possibly Electrical Capacitors dealing with the control of power factor.

Imperial Conference

The outstanding event of the year was the holding of the Imperial Economic Conference at Ottawa and the appointment of a Special Committee on Industrial Standardization, at which the Canadian Engineering Standards Association was represented by the Secretary. This conference dealt specifically with the subject of Empire Standards, with the object of securing as much uniformity as possible throughout the Empire in the encouragement of inter-empire trade. Industrial conferences were held in connection with the Standardization Committee, at which consideration was given to Steel, Lumber, Industrial Chemicals, and Agricultural Machinery. It is too early yet to say just what the result will be of this conference, but closer cooperation between Great Britain and the standardizing organizations in the various Dominions will be encouraged.

Finances

The Association operates with funds supplied by the Dominion Government through the National Research Council, and also funds secured direct from industry by a system of sustaining memberships. In spite of the prevailing depression, sufficient funds have been available for the year to carry on the work.

Change in Headquarters

The C.E.S.A. headquarters have been changed to No. 79 Sussex Street, Ottawa.

Accompanying this report is Appendix A—American Standards Approved by the American Standards Association, September 1, 1931, to September 1, 1932.

Respectfully submitted,

THE COMMITTEE ON STANDARDIZATION,

J. C. IRWIN, *Chairman.*

Appendix A

STANDARDS APPROVED BY THE AMERICAN STANDARDS ASSOCIATION

Period September 1, 1931, to September 1, 1932

ASA Symbol	*Title*	*Approved as*
A12—1932	Safety Code for Floor and Wall Openings, Railings and Toe Boards	American Standard
A47—1932	Steel Reinforcing Bars	American Standard
B8—1932	Safety Code for the Protection of Industrial Workers in Foundries	American Standard
B16bl—1931	800 Lb. Hydraulic Cast Iron Pipe Flanges and Flanged Fittings	American Standard
B38cl—1931	Code for Testing Domestic Refrigerators Using Ice	American Recommended Practice
B47—1932	Plain and Thread Plug and Ring Gage Blanks	American Standard
C8a—1932	Definitions and General Standards for Wires and Cables	American Standard
C8kl—1932	Weatherproof (Weather Resisting) Wires and Cables	American Tentative Standard
C8k2—1932	Heat Resisting Wires and Cables	American Tentative Standard
C16c—1932	Standard Vacuum Tube Base and Socket Dimensions	American Standard
C16d—1932	Manufacturing Standards applying to Broadcast Receivers	American Standard
C44—1931	Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases	American Standard
C48—1931	Standard for Electric Railway Control Apparatus	American Standard
C53—1932	Recommended Practice in the Temperature Operation of Transformers	American Recommended Practice
M5—1932	Methods of Screen Testing of Ores (Hand Method)	American Recommended Practice
M6—1931	Drainage of Coal Mines	American Recommended Practice
M24—1932	Safety Rules for Installing and Using Electrical Equipment in Metal Mines	American Recommended Practice
Z10a—1932	Symbols for Mechanics, Structural Engineering and Testing Materials	American Standard
Z12b—1931	Safety Code for the Installation of Pulverizing Systems for Sugar and Cocoa	American Standard
Z12c—1931	Safety Code for the Prevention of Dust Explosions in Starch Factories	American Standard
Z12e—1931	Safety Code for the Prevention of Dust Explosions in Terminal Grain Elevators	American Standard
Z12g—1931	Safety Code for the Prevention of Dust Explosions in Wood Flour Manufacturing Establishments	American Standard
Z12h—1931	Safety Code for the Prevention of Dust Ignitions in Spice Grinding Plants	American Standard
Z12i—1931	Safety Code for the Use of Inert Gas for Fire and Explosion Prevention	American Standard
Z21a—1932	Approval Requirements for Gas Ranges	American Recommended Practice

REPORT OF COMMITTEE III—TIES

. J. BURTON, *Chairman;*
V. ARDAGH,
S. BELCHER,
. S. BLAIKLOCK,
. C. BOLIN,
. F. BROWN,
. E. BUTLER,
OYLE CAMPBELL,
. E. CHAPMAN,
. R. CLARKE,
B. CLEMENT,
. L. COOK,
E. L. CRUGAR,
H. R. DUNCAN,
C. W. GREENE,
R. S. HUBLEY,
J. E. KING,
C. S. KIRKPATRICK,
F. C. KRELL,
L. O. LOWER,
A. F. MAISCHAIDER,
C. H. MITCHELL,
H. C. MUNSON,
L. T. NUCKOLS,
JOHN FOLEY, *Vice-Chairman;*
J. H. REEDER,
L. J. RIEGLER,
J. H. ROACH,
S. S. ROBERTS,
S. E. SHOUP,
L. L. TALLYN,
J. W. TATE,
K. G. WILLIAMS,
W. W. WYSOR,
R. C. YOUNG,
Committee.

'o the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following assigned ubjects:

(2) Extent of adherence to Standard Specifications (Appendix A).

(3) Substitutes for wooden ties (Appendix B).

(4) Tie renewal averages and costs per mile (Appendix C).

(5) Method of comparison of renewal costs per mile (Appendix D).

(7) Economics of the use of 8-ft. 6-in. and 9-ft. ties as compared with 8-ft. ties (Appendix E).

(8) Method illustrating how tie renewals may be predicted under a program involving the change from the use of untreated ties to treated ties (Appendix F).

(9) Most economical method of distributing ties from treating plants to points of use (Appendix G).

(10) Economic uses for old ties which must be removed from track and bridges (Appendix H).

(11) Tie renewal practice including methods of inspection and renewal, check of such inspection and adherence to such inspection (Appendix I).

In line with instructions, your Committee has elected not to report this year on the following assignments:

(1) Revision of Manual.

(6) Concise summary of all of the features which constitute the best tie practice.

Action Recommended

(1) That the reports contained in Appendices A, B, C, D, E, F, G, H, and I be received as information.

Respectfully submitted,

THE COMMITTEE ON TIES,
W. J. BURTON, *Chairman.*

Bulletin 351, November, 1932.

Appendix A

(2) ADHERENCE TO STANDARD SPECIFICATIONS FOR CROSS-TIES

John Foley, Chairman, Sub-Committee; W. C. Bolin, E. E. Chapman, H. R. Clarke, H. R. Duncan, C. H. Mitchell, H. C. Munson, L. T. Nuckols, J. H. Reeder, S. S. Roberts, K. G. Williams.

Fewer ties were purchased in 1932 than in 1930 or 1931, and in consequence there continued the lack of competitive conditions which tempt consumers into non-adherence to standard specifications.

In a body, the Committee on Ties did not examine any lots of ties, but reports by individual members, on observations of 5,000,000 ties at six seasoning yards, confirm the opinion that the ties now stored in sanitary surroundings by producers or railroads represent satisfactory inspection under the requirements of the standards.

The adoption of the A.R.E.A. standard by a railroad which had been using individual specifications for ties added 19,000 miles of track to the almost complete mileage of United States lines covered by the American Standard.

Millions of ties were given preservative treatment during 1932 and added to the stocks of similar ties stored until they are used. If the creosoting of these ties was not put off until decay had started in them, their treatment should keep them in sold condition until they are needed, provided standard anti-splitting irons have been effectively applied.

Whenever the demand for ties develops, there will be presented for purchase quantities of them which have been held in the woods or on rights-of-way in styles of stacks not suitable for satisfactory seasoning. Many of these ties have decayed during the varying periods their owners have awaited a change in market conditions. It will be contended that these ties are dry enough to treat without additional storage, thus saving some cost of seasoning. All such ties should be inspected with extreme care, and none accepted in stacks. Each tie should be examined with special consideration of the deterioration to be expected at those portions which have been in contact with other ties.

Appendix B

(3) SUBSTITUTE TIES

A. F. Maischaider, Chairman, Sub-Committee; S. V. Ardagh, R. E. Butler, S. B. Clement, L. J. Riegler, W. W. Wysor.

REPORTS FROM RAILWAYS MAKING TESTS OF SUBSTITUTE TIES

Atlanta & West Point Railroad

Reported by S. R. Young, Chief Engineer.
Date—July 6, 1932.

Name of tie	Duke Reinforced Cross-tie
Location	Louise, Ga.
Date put in track	June 27, 1927
Number put in track	10
Number now in track	10
Kind of ballast	Stone and gravel
Weight of rail	90-lb.
Kind of traffic	High speed, heavy service, passenger and freight

Bangor & Aroostook Railroad

Reported by P. C. Newbegin, Chief Engineer.
Date—June 14, 1932.

The concrete ties in Bangor & Aroostook Railroad tracks were inspected June 8th and showed no change whatever in the condition since last year, as reported on page 477 of AREA Bulletin 343. No ties have been removed since that report was made.

Bessemer & Lake Erie Railroad

Reported by F. R. Layng, Chief Engineer.
Date—June 10, 1932.

Cracking and disintegration of the Brown Ties have become more serious and to date 224 ties have been removed from the track.

Delaware & Hudson Railroad

Reported by M. J. McDonough, Division Engineer.
Date—June 1932.

Name of tie	Dalton Steel Tie
Location	Carbondale, Pa.
Date put in track	April 1927
Number put in track	98
Number now in track	98
Kind of ballast	Cinder
Weight of rail	90-lb. ASCE

Tests were so satisfactory that a steel tie plant was installed. Number installed to date is 52,888.

Duluth, Missabe & Northern Railroad

Reported by E. H. Dresser, Vice-Pres. & Chief Engineer.
Date—June 29, 1932.

Missabe Division—The last report showed 19,095 Carnegie Steel Ties in track, 389 having been removed during the year ending December 31, 1931, leaving balance of 18,706. The Kimball Steel Ties originally installed are all in track.

Iron Range Division—The last report showed 889 Carnegie Steel Ties in track, none being removed during the year ending December 31, 1931. The 7 Hatch Concrete Ties are all in track.

Los Angeles Railway Corporation

Reported by B. H. Eaton, Engineer Way & Structures.
Date—June 10, 1932.

Name of tie	McDonald Concrete
Location	Los Angeles
Date put in track	1911
Number put in track	627
Number now in track	584
Kind of ballast	Solid concrete
Weight of rail	87-lb.
Kind of traffic	Heavy traffic, exclusively passenger

No new installation.

Elgin, Joliet & Eastern Railway

Reported by Arthur Montzheimer, Chief Engineer.
Date—July 15, 1932.

Referring to the 62 Bates Concrete Ties installed in the year 1912; 56 remained in service on July 1, 1932. Two were removed during the month of June 1930, on account of tie rods, or reinforcing rods being rusted through at the end of the concrete in center of track, as reported October 22, 1930. Four ties were removed during month of August, 1931, for the same reason as those taken out of service during June 1930. At present, six of the remaining ties have the two upper reinforcing rods rusted through but the two bottom rods in the center of track are still in fair condition and ties will remain in service.

The following statement shows the Carnegie Steel Switch and Steel Cross Ties installed in our tracks to July 1, 1932, the number taken up to the same date and the quantity in track as of July 1, 1932. All other characteristics in connection with the kind of ballast, weights of rail, etc., remain unchanged from that previously reported.

Year	*Lin. ft. steel switch ties laid in renewals*	*Lin. ft. steel switch ties taken up acct. renewals*	*Lin. ft. steel switch ties laid in construction*	*Lin. ft. steel switch ties taken up acct. track retired*
1912	30452		5580	
1913	196333		11527	430
1914	142939		5135	
1915	58314		2023	1615
1916	17856	10	7120	16498
1917	3789	1907	8623	17340
1918	4511	3006	6564	5453
1919	6483	526	1582	1582
1920	575	22737	2588	2774
1921	4712	24855	717	4744
1922	241	21903	444	527
1923	846	19451	1973	
1924	2300	18124	441	1394
1925	180	33700		2271
1926	1708	37098	255	2550
1927	0	142954	2004	945
1928	0	77891	0	0
1929	0	17794	0	0
1930	0	1688	0	401
1931	0	660	0	438
Jan. 1 to June 30, 1932	0	955	0	0
Total	471239	425259	56576	58962

Linear feet of steel switch ties laid in renewals	471239
" " " " " " " construction	56576
	527815
Linear feet of steel switch ties taken up acct. renewals	425259
" " " " " " " " track retired	58962
	484221
Linear feet of steel switch ties in track July 1, 1932	43594

Steel Cross-Ties

Number of steel cross-ties laid in track	15514
" " " " taken up	12040
" " " " in track July 1, 1932	3474

Steel cross-ties renewed as follows:

Year	*Number*
1916	50
1917	260
1918	182
1919	453
1920	306
1921	1165
1922	641
1923	2620
1924	1341
1925	262
1926	550
1927	2399
1928	1276
1929	0
1930	0
1931	529
1—1—32 to 7—1—32	6
	12040

Pennsylvania Railroad

Reported by T. J. Skillman, Chief Engineer.
Date—Sept. 14, 1932.

On account of present restricted conditions, no report will be made this year of the substitute ties in track.

St. Louis–San Francisco Railway

Reported by F. G. Jonah, Chief Engineer.
Date—July 8, 1932.

Name of tie	Clark–Applegate
Location	Springfield, Mo.
Date put in track	December 1914
Number put in track	125
Number now in track	120
Kind of ballast	Cinders, gravel and chatts
Weight of rail	85-lb.
Kind of traffic	Heavy service, exclusively freight

Ties are getting very badly corroded and the lugs holding the wood fillers in place are pretty weak. Five of the ties were removed during the last year account complete failure of the metal lugs holding the wooden fillers.

Terminal Railroad Association of St. Louis

Reported by H. J. Pfeifer, Chief Engineer.
Date—June 29, 1932.

Name of tie	Miller
Location	Near Florissant Ave., St. Louis, Mo.
Date put in track	May 1924
Number put in track	100
Number now in track	100
Kind of ballast	Cinder
Weight of rail	100-lb. ARA–B section
Kind of traffic	Moderately heavy freight and passenger service—medium speed

The Miller Ties, on which we have been making annual reports, were installed in the track in May 1924. They are still in track and in first-class condition, none of them having been removed and no expense of any kind having been incurred in connection with them since they were installed. Judging from their present condition, there is every reason to expect a life for these ties of 30 years or more.

SUMMARY OF TESTS OF SUBSTITUTE TIES, NOW IN PROGRESS, 1932

Railroad	Name of Tie	Location	Date Put in	Number Put in	Number Now in	Ballast	Rail Section, Pounds	Traffic
Atlanta & West Point	Duke	Louise, Ga.	1927	10	10	Stone and gravel	90	A
Bangor & Aroostook	Maine	Hudson, Me.	1923–24	69	68	Gravel	85	A
Bessemer & Lake Erie	Brown	Oakmont, Pa.	1930	1,500	1,276	Slag	130	C
Delaware & Hudson	Dalton Steel Tie	Carbondale, Pa.	1927	98	98	Cinder	90	E
	Dalton Steel Tie	Various	1927–31	52,888	52,888	Cinder	90	E
Duluth, Missabe & Northern: Missabe Division	Carnegie Steel Tie	Various	1908–09	22,380	18,706	Crushed Rock	100	A
	Kimball Steel Tie	Virginia, Minn.	1914	30	30	Gravel	100	C
Iron Range Division	Carnegie Steel Tie	Various	1905	2,000	889	Gravel	80	C
	Hatch Concrete Tie	Two Harbors, Minn.	1923	11	7	Gravel	80	C
Elgin, Joliet & Eastern	Bates Concrete Tie	Whiting, Ind.	1912	62	56	Crushed Rock	85	C
	Carnegie Steel Tie	Various	1909–18	15,514	3,474	Gravel, Cinders, Slag	85–100	C
	Carnegie Steel Tie (switch)	Various	1912–27	527,815*	43,594*	Gravel, Cinders, Slag	85–100	C
Los Angeles Railway	McDonald Concrete	Los Angeles, Cal.	1911	4,323	584	Solid Concrete	87	B
Pennsylvania	Riegler Concrete	Emsworth, Pa.	1908	15	No report for 1932	Stone	130	A
	Snyder Composite	Pittsburgh Div. Yds.	1907	2,255		Cinder	100	F
	Brown Concrete	Aspinwall, Pa.	1925	100		Cinder	130	C
		Hayes, Pa.	1925	410		Stone	130	C
		Monongahela, Pa.	1927	2,516		Cinder	130	A
		Wilkinsburg, Pa.	1928	1,861		Stone	130	E
		Pitcairn, Pa.	1928	3,336		Cinder	130	C
		Derry, Pa.	1927	1,978		Cinder	130	E
		Compitt Jct., Pa.	1927	2,843		Stone	130	C
		Tunnelton, Pa.	1928	2,385		Cinder	130	A
		Bellwood, Pa.	1927	3,006		Stone	130	C
		Highspire, Pa.	1927	1,486		Cinder	130	C
		M.P. 31-A. & S. Branch	1927	517		Cinder	130	C
		Haines, Pa., C. & P. D.	1927	970		Stone	130	A
		Conowingo, C. & P. D.	1927	1,986		Stone	130	A
		Octoraro, Pa. C. & P. D.	1927	1,993		Stone	130	A
Southern Pacific Lines	U. S. Indestructible	Eagle Pass, Tex.	1916	23		Cinder	80	D
St. Louis–San Francisco	Clark-Applegate	Springfield, Mo.	1914	125	120	Cinder, Gravel, Chatts	85	C
Terminal R. R. Assn. of St. Louis	Miller	St. Louis, Mo.	1924	100	100	Cinder	100	A

*Linear Feet

A —High speed, heavy service, passenger and freight.
B —High speed, exclusively passenger.
B1—Slow speed, exclusively passenger.
C —Heavy service, exclusively freight.
D—Main track, light service.
E—Yard track with heavy switching.
F—Yard track with light switching or storage usage.

TESTS OF SUBSTITUTE TIES IN THE UNITED STATES

NAME OF TIE	RAILROAD	LOCATION	No. Put In	Date Put In	Max. Life Secured	REMARKS
Travis	P.W.& B.	Lamokin	100	1878	4 Yr.7 Mo.	Formerly Phila.& Balto.Cent.
Travis	P.W.& B.	Chester Creek Branch	100	1879	4 Years	———
P.R.R.	Penna	Filbert St.Exten.	—	1880	———	Inverted Trough Section
P.R.R.	Penna	West Phila.	500	1885	———	Inverted Trough Section
International	Maine Cent.	Portland, Me.	Few	1885	———	No record of life available
Toucey	NYC&HR	Grand Cent.Station	1000	1885	———	In service over five years
International	B.& M.	Sommerville, Mass.	Few	1885	4 Years	———
Taylor	Sante Fe	Streator, Ill.	22	1887	7 Years	Also known as Columbian Tie
Webb	Penna	Menlo Park, N.J.	880	1887	9 Years	London & N.W. Standard Track
Webb	Penna	Huntingdon, Pa.	880	1887	4 Years	London & N.W. Standard Track
Krupp	D&RG	Denver	Few	1887	—	Taken out after short time.
International	Long Isl.	———	20	1887	———	No record of life available.
Standard	C&WI	Chicago	500	1889	10 Years	Tie very similar to "Universal"
Hartford	NYC&HR	Garrison, N.Y.	800	1889	10 Years	———
Standard	D&H	Saratoga Springs	1500	1890	1 Year	———
Standard	Long Isl.	———	500	1891	5 Years	———
Hammond	Rch.& Dan.	———	2	1890-1	———	No record of service available
Standard	P.& R.	Philadelphia	1000	1891	3 Years	———
Saunders	NYC&HR	Grand Central Station	—	1891	———	No record of service available
Saunders	I&GN	Austin, Tex.	—	1891	———	" " " "
Daniels	NYLE&W	Youngstown	17	1891	———	" " " "
Hicks	DL&W	Hoboken	6	1891	———	" " " "
Morrell	DL&W	West End & Summit,N.J.	100	1892	———	" " " "
Morrell	DL&W	Scranton, Pa.	100	1892	———	" " " "
Price	P.& R.	Germantown Branch	200	1893	———	" " " "
Golder	NYC	Cleveland	6	1894	———	" " " "
Hartford	NYC&HR	110th St.,N.Y.	1350	1896	3 Years	Modified type;also called "Schoen"
Bidwell	C&A	Kansas City	—	1897	—	No record of service available
Harrell	PFW&C	Union Sta.,Chicago	30	1899	17 Mos.	Reinforced concrete
Chester	H&BTM	Huntingdon, Pa.	—	1899	—	No record of service available
Kimball	Pere M.	Saginaw	2	1900	—	———
Inverted Trough	B&LE	Osgood, Pa.	1500	1900	11 Years	———
Kimball	Pere M.	Port Huron	1	1900	—	———
Harrell	Penna	Hagewisch	10	1901	—	On industry track
Reinforced Conc.	Colo.& S.	Argo, Colo.	3	1901	1 Year	———
Buhrer	NYC	Sandusky	150	1901	—	Ties made of old 65-lb. rail
Buhrer Conc.	NYC	Sandusky	2095	1902	—	Conc.base around old 65-lb. rail
Burbank	Hecla M.Co.	Bay City	2	—	—	No record of service available
Buhrer Conc.	C&NW	Milwaukee	15	1902	12 Years	Located at Allis
Buhrer Conc.	Ann Arbor	—	77	—	—	No record of service available
Buhrer Conc.	L & M	Banbury, O.	550	—	—	———
Alfred	P.M.	Saginaw	14	1902	—	3 still in track in 1932
Kimball	P.M.	Bay City	2060	1902	—	Still in track in 1932
Buhrer Conc.	Penna	Toledo	50	1903	2½ Years	———
Seeley	Toledo Term.	Toledo	10	1903	2 weeks	Concrete without reinforcement
Buhrer	LE&W	Tipton, Ind.	24	1903	21 Years	Last 5 removed in 1924
Kimball	P.M.	Walkerville,Ont.	2	1903	—	Removed before 1920
Buhrer	Penna	N.W.Sys.	600	1903	3 Years	———
Kimball	NYC&StL	Cleveland	8	1903	9 Years	All removed 1910-1912 account grade elimination.
Kimball	P.M.	Pelton, Ont.	2	1903	—	Removed before 1920.
Buhrer Conc.	Penna	Emsworth	21	1904	2 Mos.	———
Carnegie	NYC	Castleton	1 mi.	1904	1 Year	———
Buhrer Conc.	Penna	Toledo	50	1904	2½ Years	———
Buhrer Conc.	Penna	Emsworth	500	1904	2½ Years	———
Seitz	Penna	Emsworth	2	1904	5 Years	———
Affleck	NYC	Chesterton, Ind.	15	1904	4 Mos.	———
Buhrer	NYC	Sandusky	1 mi.	1904	—	———
Reinforced Conc.	U&D	Rondout	—	1904	—	———
Alfred	P.M.	Various	233	1904	11 Years	———
Brunson	Chgo.Jct.	Chicago	19	1904	Few Mos.	———
Buhrer Conc.	Penna	Emsworth	100	1904	2½ Years	-
Affleck	Penna	Emsworth	100	1904	7 Mos.	Last removed April 1905
Boughton	B&O	Akron,O.	17	1904	—	Last removed in 1920

TESTS OF SUBSTITUTE TIES IN THE UNITED STATES

NAME OF TIE	RAILROAD	LOCATION	No. Put In	Date Put In	Max. Life Secured	REMARKS
Seitz	Penna	Emsworth	49	1904	2 Years	———
Buhrer Conc.	Penna	Emsworth	100	1904	2 Years	Replaced part of 300 previously under test
Carnegie	B&LE	Various	Many	1905 & Sub.	——	213,980 in track in 1931
Buhrer	Penna	Emsworth	500	1905	2 Years	Steel ties
Carnegie	D&IR	Various	2000	1905	——	889 still in track in 1931
Kimball	NYC&StL	Cleveland	6	1905	7 Years	———
Manson	Penna	Emsworth	500	1905	12 Years	Moved twice acct. inability to insulate
McCune	Mon.Conn.	Pittsburgh	45	1905	2 Years	———
Bowman	Penna	Emsworth	5	1905	1 day	———
Kimball	C&A	Lockport, Ill.	63	1905	8 Years	———
Keefer	Penna	Scully Yard	44	1905	7 Mos.	———
Jennings	B&O	Baltimore	5	1906	2¼ Years	———
Carnegie	BR&P	Golden, N.Y.) Ridgeway, Pa.)	3000	1906	12 Years	———
Percival	FEC	St.Augustine	16	1906	14 Years	Removed 1920 acct. laying heavier rail. Ties in good condition.
Carnegie	B&M	Boston	Set Sw.	1906	7 Years	———
Carnegie	N.P.	——	60	1906	——	No record available
Carnegie	L.V.	——	—	1906	——	" " "
Carnegie	LC&N	——	48	1906	——	Still in track in 1932
Snyder	Corn.& Leb.	Mt.Gretna, Pa.	200	1906	——	Still in track in 1920
Percival	P&LE	McKees Rocks	25	1906	20 Mos.	———
Carnegie	B&O	Mariettaville	1 mi.	1906	10 Years	———
Percival	Sou.Pac.	Edgewater, Tex.	100	1906-8	17 Years	Last 31 removed in 1923
Chenoweth	Penna	Scully Yard-	100	1906	7 Years	Last 10 removed in 1913
McDonald	AT&SF	Los Angeles	21	1907	11 Years	Removed in 1918
Hickey	M.C.	Various	40	1907	——	———
Corell	Buffalo Crk.	——	30	1907	——	No record available
Carnegie	PS&N	Byrndale Branch	795	1907	20 Years	Last 27 removed in 1927
Snyder	Penna	Conemaugh & Derry	2255	1907	——	1157 still in track in 1930
Carnegie	P&LE	McKees Rocks	3000	1907	9 Years	———
Carnegie	Big Four	Greensburg, Ind.	3000	1908	——	Last 1952 ties removed in 1926
Riegler	Penna	Emsworth	15	1908	——	14 still in track in 1930
Carnegie Wedge	P&LE	Pittsburgh	6	1908	8 Years	———
Carnegie	Lake Term.	Lorain, O.	—	1908	——	———
Carnegie Wedge	Union RR	Pittsburgh	5000	1908	——	———
Atwood	P&LE	McKees Rocks	5	1908	16 Years	Removed in 1923
Carnegie	DM&N	Duluth & Proctor	22400	1908	——	18076 in track in 1932
Metal Tie Co.	B&O	Martinsburg, W.Va.	50	1909	——	All removed in 1924
Carnegie	Erie	Bergen Yard	Set Sw.	1909	6½ Years	———
Carnegie	Long Island	Hicksville	30	1909	——	Last 6 removed in 1929
Carnegie	Erie	Cleveland	Set Sw.	1909	5 Years	———
Coffman	N&W	Bluefield, W.Va.	—	1909	——	Special track construction
Carnegie	Erie	Jamestown	384	1909	——	Removed from track in 1919
Israel	Big Four	Paris, Ill.	20	1909	3 Years	———
Snyder	Midvale Steel	Midvale	1600	1909	7 Years	———
Bruckner	Penna	Scully Yard	18	1909	1½ Years	———
Carnegie	EJ&E	Various	15514	1909-17	——	3474 in track in 1932
Carnegie	EJ&E	Various	527815'	1909-17	——	43594 lin.ft. in track in 1932
Percival	Sou.Pac.	Bayou Sale	100	1910	——	Last 72 removed in 1921
Baird	AT&SF	Newton, Kans.	3	1910	15 Years	Removed in 1925
Bohm	Penna	Sewickley	12	1910	6 Years	———
Carnegie	EJ&E	So.Chicago	—	1910	——	Large part still in track in 1919
Mechling & Smith	Penna	Wilkinsburg	100	1910	12 Years	Last removed in April 1922.
Universal	Penna	Emsworth	98	1910	2½ Years	———
Universal	P&LE	Pittsburgh	100	1911	5 Years	———
Universal	NYC&HR	——	99	1911	4 Years	———
Universal	AT&SF	Braddock, Kans.	106	1911	11 Years	Moved to Florence 1912 & removed from track in 1922.
Universal	CB&Q	Chicago	100	1911	6 Years	All removed in 1917.
Universal	AT&SF	Chicago	83	1911	8 Years	Removed from track in 1919
Bruckner	Penna	Scully Yard	20	1911	14 Mos.	———

TESTS OF SUBSTITUTE TIES IN THE UNITED STATES

NAME OF TIE	RAILROAD	LOCATION	No. Put In	Date Put In	Max. Life Secured	REMARKS
McDonald	L.A.St.Ry.	Los Angeles	4323	1911	——	584 in track in paved streets 1932
Kimball Steel	DM&N	——	1	1911	——	Still in track in 1931
Bruckner	P&LE	McKees Rocks	20	1911	4 Years	——
Carnegie	Penna	Pitcairn Yard	5000'	1911	10 Years	Last 500 lin.ft. removed 1921
Weller & Reece Con.	AT&SF	Los Angeles	9	1911	2 Years	——
Kimball	Penna	Scully Yard	1	1911	6 Years	——
International	P&LE	Glassport	16	1911	4 Years	——
Simplex	C&A	Near Chicago	63	1912	6 Years	——
Bates	EJ&E	Whiting	62	1912	——	56 in track in 1932
Reinforced Conc.	AT&SF	Topeka	6	1912	3 Years	——
Morgan	Penna	Atglen, Pa.	200	1912	3 Years	——
Conc.& Steel	Long Island	L.I.City	34	1912	16 Years	Last removed in 1928.
Maxey	P&LE	Glassport	10	1912	4 Years	——
Shane	U.P.	Denver	33	1912	4 Years	——
Shane	D&SL	Denver	26	1912-16	——	22 still in track 1932
Hanna Cement	AT&SF	Rivera, Cal.	8	1912	——	Last removed in 1924
Penna Steel Co	Penna	Atglen, Pa.	5	1913-4	4 Years	——
Saxon	AT&SF	Tecumseh, Okla.	33	1913-4	——	All removed by 1917
Wolf	RR&P	Riverside, Cal.	60	1913	——	58 still in track in 1921
Carnegie	Penna	Atglen, Pa.	3000	1913	5 Years	——
Champion	Penna	Emsworth	203	1913	3 Yr.5 Mo.	——
Carnegie	AT&SF	Chanute, Kans.	55	1913	6 Years	——
Carnegie Switch	AT&SF	Newton, Kans.	46	1913	——	11 still in track in 1920. 35 destroyed by derailment in 1914.
Carnegie Switch	AT&SF	Newton, Kans.	35	1914	9 Years	Replacing those destroyed by derailment. All removed in 1923.
Leonard	Penna	Atglen, Pa.	6	1914	4 Years	——
Standard	P&LE	Glassport	20	1914	——	All removed in 1926
Kimball	DM&N	Virginia	30	1914	——	All still in track in 1930
Goodlett	Sou.Pac.	Oakland, Cal.	12	1914	1 Year	——
Conc.Roadbed	N.P.	Nisqually Rvr., Wash.	2000'	1914	——	Special track construction - still in service 1919.
Bronson	AT&SF	Chillicothe	11	1914	——	All removed in 1923
Carnegie	Penna	Atglen, Pa.	100	1914	4 Years	Removed in 1918
Clark (Applegate)	StL&SF	Springfield,Mo.	125	1914	——	120 still in track in 1932
Grant	StL&SF	Sapulpa, Okla.	4	1914	——	All removed in 1925
Stoneback	H&BTM	Huntingdon, Pa.	3	1915	——	All in track in 1920
Standard	Penna	Lenover, Pa.	500	1915	——	All removed in 1921
Snyder	Penna	Atglen, Pa.	970	1915	19 Mos.	——
Morgan	Penna	Atglen, Pa.	56	1915	10 Mos.	——
Ickes	AT&SF	Chanute, Kans.	7	1915	5½ Years	——
Waples	Penna	Atglen, Pa.	6	1916	11 Mos.	——
Shane	Penna	Atglen, Pa.	100	1916	2½ Years	——
Indestructible	Sou.Pac.	Eagle Pass, Tex.	23	1916	——	All still in track in 1930
Peerless	C&A	Chicago	201	1916	16 Years	151 still in service in 1932
Munalow	W&LE	Jewett, O.	25	1916	8 Years	Last 15 removed in 1924
Goodlett	Sou.Pac.	Pleasant Hill, Cal.	150	1917	Few Mos.	——
Goodlett	Sou.Pac.	Oakland	27	1917	——	2 still in track in 1924
Hardman	B&O	W.Baltimore	29	1917	——	All removed in 1919
La Guna (Weber)	AT&SF	Vegela, Cal.	46	1917	8 Years	Last removed in 1925
Moore	Sou.Pac.	Lafayette, La.	40	1917	——	38 still in track in 1922
Hardman	DL&W	East Dover, N.J.	30	1918	——	Last 22 removed in 1924
Silver	NYC	Spuyten Duyvil	5	1918	——	All still in track in 1923
American Conc.	Nor.& Ports.	Portsmouth, Va.	138	1919-23	——	Last few removed in 1932
Maryland	Penna	Lenover, Pa.	25	1919	——	All removed in 1920
Chamberlain	TRRAssn.	St.Louis	10	1920	——	In yard track. All removed 1926.
Champion	Penna	Lenover, Pa.	395	1920	——	Last 767 removed in 1925
Wyckoff	B&O	Baltimore	4	1921	4 Yr.10 M.	All removed in 1926
Ickes	Kan.Cty.Sou.	Kansas City	27	1921	11 Years	Removed from main line 1922 and placed in industry track. All still in service in 1932.
Metal Safety	Penna	Wampum, Pa.	20	1922	5 Years	All removed in 1927
Silver	Penna	Atglen, Pa.	148	1922	1 Year	Removed in 1923
Hatch	D&IR	Two Harbors, Minn.	11	1923	——	7 still in track in 1932
Indestructible	DT&I	Detroit	50	1923	——	All removed 1925 account being damaged by derailment.
Silver	Penna	W.Morrisville,Pa.	102	1923	6 Years	98 removed in 1929
Maine	Ban.& Aroos.	Hudson, Me.	69	1923	——	All still in track in 1930
King Conc.	Long Island	Jamaica Sta.	33	1924	——	Last 32 removed in 1930
Miller	TRRAssn.	St. Louis	100	1924	——	All still in track in 1932
Brown	Penna	Various	510	1925	——	498 still in track in 1930
Indestructible	Sou.Pac.	Houston, Tex.	100	1926	——	Last 98 removed in 1928
Brown	Penna	Various	17295	1927	——	16815 still in track in 1930
Duke	A&WP	Louise, Ga.	10	1927	——	All still in track in 1932
Willis Conc.	Penna	Manhattan	24	1927	4 Years	All removed in 1931
Brown	Penna	Various	7582	1928	——	7581 still in track in 1930
Dalton	D&H	Various	52888	1928-31	——	All still in track in 1932
Brown	B&LE	Oakmont, Pa.	1500	1930	——	1276 still in track in 1932

Appendix C

(4) TIE RENEWAL AVERAGES PER MILE MAINTAINED

J. H. Roach, Chairman, Sub-Committee; M. S. Blaiklock, S. B. Clement, L. T. Nuckols, J. H. Reeder, L. J. Riegler, S. S. Roberts.

Tables A and B herewith give the 1931 renewals as reported to the Interstate Commerce Commission, or in the case of the Canadian Railways, as reported to the Committee in the same form.

The tables also include the density of traffic figures which were begun two years ago. It is believed that these density of traffic figures will be useful when making comparisons of items of track maintenance other than ties, as well as when ties are the subject of inquiry.

The year 1931 is the fifth year for which the tie renewal data has been reported as in Tables A and B. In accordance with the intention announced when the first year's data was presented, five-year averages are now included for the first time.

These five-year averages will be found in Table C, and, as reported this year, include the years 1927 to 1931. The averages are weighted; that is, they were obtained by dividing total ties or dollars, as the case may be, by the sum of maintained miles for each of the five years.

Appendix D

(5) METHOD OF PROPER COMPARISON OF RENEWAL COSTS PER MILE MAINTAINED, WITH ADJUSTMENT FOR VARIABLES SUCH AS TRAFFIC DENSITY, RATE OF INSTALLATION OF TREATED TIES, ETC.

S. E. Shoup, Chairman, Sub-Committee; S. V. Ardagh, W. C. Bolin, H. F. Brown, R. E. Butler, E. L. Crugar, John Foley, C. S. Kirkpatrick, A. F. Maischaider, L. J. Riegler, J. H. Roach, S. S. Roberts, L. L. Tallyn.

Renewal costs of cross-ties laid in replacement per mile of maintained track as reported by this Committee in Table B of Appendix C are affected by

A. Number of ties renewed per mile, which in turn depends upon:

1. Tie conditions, such as,
    - a. Percentage of untreated ties in track
    - b. Kind of wood
    - c. Kind of treatment
    - d. Size of ties
    - e. Spacing of ties
    - f. Preboring and adzing of ties
2. Road and track conditions, such as,
    - a. Gradient of track
    - b. Alignment of track
    - c. Roadbed drainage
    - d. Kind, condition and distribution of ballast
    - e. Conditions affecting mechanical wear
        - (1) Weight of rail
        - (2) Tie plate dimensions
        - (3) Plate and rail fastenings
    - f. Frequency of rail renewals
    - g. Frequency of track surfacing
    - h. Frequency of regaging

CROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

Sheet 1 of 5

Road	Wooden ties untreated (U) Number	Wooden ties untreated (U) Average Cost	Wooden ties Treated (T) Number	Wooden ties Treated (T) Average Cost	Ties other than wood (S) and second hand re-applied	Total Ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Equated gross ton-miles d
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND REGION:									
Bangor & Aroostook	200,571	$ .78	-	-	-	200,571	849.30	2,443,345	1,528,938,600
Boston & Maine	90,264	1.12	487,872	$1.75	-	* 578,136	3,514.81	10,712,000	15,480,798,536
Canadian National Lines in N.E.	7,182	.81	14,976	1.81	-	22,158	255.59	786,025	504,748,640
Canadian Pacific Lines in Maine	2,579	.44	53,527	1.43	-	56,106	214.05	617,529	1,032,613,752
Canadian Pacific Lines in Vermont	334	.57	31,087	1.44	-	31,421	123.80	416,857	610,082,520
Central Vermont	-	-	131,897	1.78	-	131,897	556.89	1,750,000	2,458,506,560
Maine Central	214,782	.98	89,378	1.58	-	304,160	1,371.49	4,160,000	3,893,113,128
New York Connecting	-	-	7,703	1.98	-	7,703	26.30	82,861	347,462,376
New York, New Haven & Hartford	1,145	.52	795,823	1.68	-	796,968	4,831.43	13,805,980	22,074,595,920
Rutland	49	.87	110,384	1.61	-	110,433	525.78	1,578,213	1,850,079,936
GREAT LAKES REGION:									
Ann Arbor	-	-	47,631	1.54	-	47,631	418.47	1,254,960	1,456,515,760
Buffalo, Rochester & Pittsburgh	8,751	1.00	47,665	1.93	-	56,416	961.79	2,678,585	4,969,965,488
Delaware & Hudson	13,642	1.09	151,305	2.52	(S) 13,992	178,939	1,486.80	4,588,862	9,531,553,848
Delaware, Lackawanna & Western	556	.83	186,808	1.86	-	187,364	2,478.38	7,255,568	17,632,821,912
Detroit & Mackinac	1,446	.44	28,107	1.14	* 142	29,697	303.64	910,908	275,535,088
Detroit & Toledo Shore Line	-	-	12,708	2.11	* 294	13,002	152.14	467,737	549,972,000
Erie (Inc.Chgo.& Erie)	4,547	.75	877,317	1.97	-	881,864	5,087.28	14,573,553	37,834,977,424
Grand Trunk Western	149,883	1.07	153,573	1.63	-	303,456	1,947.93	6,339,933	7,029,512,832
Lehigh & Hudson River	111	1.25	7,071	1.86	-	7,182	132.23	345,200	731,539,888
Lehigh & New England	1,700	.73	30,795	2.01	-	32,495	305.06	905,453	859,798,688
Lehigh Valley	-	-	165,219	1.84	-	165,219	3,126.04	9,261,100	16,803,302,960
Monongahela	31,565	1.46	4,749	2.30	-	36,314	250.33	721,010	954,180,800
Montour	2,593	1.37	10,477	1.97	-	13,070	80.10	224,280	314,436,000
New Jersey & New York	-	-	8,257	1.80	-	8,257	57.05	164,304	318,055,056
New York Central	50,082	1.00	2,059,280	1.80	* 13,705	2,123,067	22,979.46	71,412,945	150,810,817,504
New York, Chicago & St. Louis	503	.98	196,474	1.88	-	196,977	2,809.69	8,389,888	14,853,462,816
New York, Ontario & Western	1,031	.96	104,548	1.70	(S) 50	105,629	909.42	2,590,035	3,945,914,064
New York, Susquehanna & Western	39	1.73	29,844	1.63	-	29,883	238.86	689,262	622,153,504
Pere Marquette	5,904	.45	553,468	1.69	-	559,372	2,935.79	8,809,130	9,430,025,960
Pittsburgh & Lake Erie	98	1.49	3,399	1.85	-	3,497	959.62	2,872,295	4,144,570,720
Pittsburg & Shawmut	20,592	.86	-	-	* 122	20,714	129.57	359,897	225,519,288
Pittsburgh & West Virginia	23,751	1.29	-	-	-	23,751	202.76	588,009	493,893,008
Pittsburg, Shawmut & Northern	26,302	1.01	13,169	1.80	-	39,471	239.39	695,738	370,929,840
Ulster & Delaware	4,184	.90	2,937	1.50	-	7,121	158.14	432,134	254,155,360
Wabash	14,757	.61	385,630	1.24	-	400,387	3,361.00	10,444,885	21,249,025,544

TABLE A

CROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

Sheet 2 of 5

Road	Wooden ties untreated (U) Number	Wooden ties untreated (U) Average Cost	Wooden ties Treated (T) Number	Wooden ties Treated (T) Average Cost	Ties other than wood (S) and second hand re-applied	Total Ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Equated gross ton-miles d
1	2	3	4	5	6	7	8	9	10
CENTRAL EASTERN REGION:									
Akron, Canton & Youngstown	24,890	$ 1.84	-	$ -	-	24,890	215.92	621,831	353,016,608
Atlantic City	29	.67	35,273	2.02	-	35,302	310.18	875,425	921,189,896
Baltimore & Ohio	343	.98	448,851	1.59	-	449,194	9,766.94	27,834,005	57,610,503,792
Bessemer & Lake Erie	40,549	1.41	81,970	2.22	(S) 317	122,836	515.11	1,609,789	2,325,760,928
Buffalo & Susquehanna	47,151	1.26	13,220	1.98	-	60,371	299.54	844,703	381,316,576
Central R.R. of New Jersey	-	-	124,618	1.84	-	124,618	1,524.06	4,290,303	8,842,452,824
Chicago & Eastern Illinois	-	-	151,687	1.48	-	151,687	1,545.79	4,793,340	6,128,379,216
Chicago & Illinois Midland	66	.74	16,786	1.40	-	16,852	159.82	481,625	695,265,824
Chicago, Indianapolis & Louisville	456	.90	87,437	1.30	* 2,575	90,468	888.19	2,735,119	4,054,732,384
Detroit, Toledo & Ironton	3,421	.58	42,164	1.74	-	45,585	643.78	1,854,086	1,421,367,400
Elgin, Joliet & Eastern	-	-	151,295	1.50	* 16,358	167,653	915.81	2,828,302	2,667,035,000
Illinois Terminal	20,342	.82	40,877	1.46	* 1,309	62,528	729.41	1,973,000	1,361,427,768
Long Island	2,082	1.21	76,635	1.86	-	78,717	866.96	2,432,945	8,468,465,208
Missouri-Illinois	52,312	.67	1,974	1.10	-	54,286	245.62	761,200	245,935,824
Pennsylvania R.R.	33,327	1.28	1,678,992	1.85	(S) 534	1,712,319	22,803.98	4,053,555	162,783,153,080
Reading Company	-	-	338,767	1.79	(S) 50	338,817	3,213.62	9,016,939	18,055,817,432
Staten Island Rapid Transit	-	-	6,456	2.06	-	6,456	103.67	284,637	-
Western Maryland	94,969	.92	132,439	1.54	-	227,408	1,219.23	3,511,391	4,863,306,304
Wheeling & Lake Erie	15,798	1.03	100,198	1.60	* 450	116,446	870.34	2,621,714	2,855,432,600
POCAHONTAS REGION:									
Chesapeake & Ohio	16,829	1.16	653,082	1.24	-	669,911	5,273.07	16,227,535	48,337,239,832
Norfolk & Western	566	.58	724,109	1.30	-	724,675	4,412.89	13,679,959	31,799,432,664
Richmond, Fredericksburg & Potomac	112,140	.97	-		* 987	113,127	379.50	1,086,500	3,454,995,176
Virginian	105,450	.75	93,231	1.42	* 610	199,291	849.31	2,677,695	5,344,121,480
SOUTHERN REGION:									
Alabama Great Southern	19,409	.83	169,878	1.50	-	189,287	551.54	1,701,813	2,509,048,464
Atlanta & West Point	129	1.14	26,604	1.42	-	26,733	b 166.84	c 440,458)	1,217,407,632
Western Ry. of Alabama	354	.70	35,972	1.43	-	36,326	b 212.54	c 561,106)	
Atlanta, Birmingham & Coast	58,760	.97	118,875	1.10	-	177,635	799.64	2,300,884	1,538,708,544
Atlantic Coast Line	522,778	.89	920,358	1.09	-	1,443,136	6,880.27	19,983,951	21,138,655,712
Central of Georgia	36,519	.74	329,104	.86	-	365,623	2,559.67	7,140,400	7,318,609,912
Charleston & Western Carolina	101,315	1.08	-	-	-	101,315	427.27	1,184,392	799,673,840
Cincinnati, New Orleans & Tex.Pac.	12,652	.88	206,330	1.58	-	218,982	780.09	2,412,706	6,233,819,048
Clinchfield	117,623	.78	42,939	1.55	-	160,562	401.94	1,221,900	2,025,528,504
Columbus & Greenville	10,907	.77	20,312	1.31	-	31,219	205.28	650,327	306,156,416
Florida East Coast	49,207	.97	2,629	.65	-	51,836	1,526.77	4,382,790	3,584,042,792
Georgia R.R.	39,591	1.18	65,762	1.47	-	105,353	439.46	1,297,363	1,546,166,072

TABLE A

CROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

Sheet 3 of 5

Road	Wooden ties untreated (U) Number	Wooden ties untreated (U) Average Cost	Wooden ties Treated (T) Number	Wooden ties Treated (T) Average Cost	Ties other than wood (S) and second hand re-applied	Total Ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Equated gross ton-miles d
1	2	3	4	5	6	7	8	9	10
SOUTHERN REGION (CONT'D)									
Georgia & Florida	131,167	$ .64	-	$ -	-	131,167	511.92	1,385,019	419,798,496
Georgia, Southern & Florida	101,210	.96	20,035	1.36	-	121,245	472.81	1,473,937	1,347,466,408
Gulf & Ship Island	70	1.39	105,461	1.02	-	105,531	366.90	1,131,767	538,418,312
Gulf, Mobile & Northern	9,935	.69	90,002	1.08	-	99,937	681.30	2,180,160	1,590,677,728
Illinois Central	44,019	1.25	1,280,001	1.14	(S) 60	1,324,080	7,990.44	24,361,505)	50,840,077,904
Yazoo & Mississippi Valley	39,424	1.20	483,122	1.21	-	522,546	2,213.08	6,769,012)	
Louisville & Nashville	132,570	1.19	1,090,488	1.67	-	1,223,058	7,262.65	21,151,552	35,478,714,280
Mississippi Central	1,957	.75	26,503	1.04	-	28,460	170.19	536,060	226,563,504
Mobile & Ohio	354,485	.70	14,586	.96	-	369,071	1,205.05	4,071,025	4,175,098,960
Nashville, Chattanooga & St. Louis	2,659	.59	501,519	1.29	-	504,178	1,579.21	4,691,472	6,140,226,864
New Orleans & Northeastern	1,281	1.10	70,519	1.43	-	71,800	289.40	892,901	1,387,926,680
New Orleans Great Northern	1,139	.77	37,430	1.04	* 2,647	41,216	291.56	933,001	566,630,376
Norfolk Southern	249,933	.74	-	-	-	249,933	1,093.85	3,115,466	1,780,693,904
Northern Alabama	48,689	.86	-	-	-	48,689	138.61	438,882	202,329,008
Seaboard Air Line	1,192,026	.90	282,231	1.01	-	1,474,257	5,707.89	17,726,200	17,481,057,312
Southern Ry.	1,989,927	.86	1,022,320	1.47	-	3,012,247	8,961.17	28,471,527	37,575,663,120
Tennessee Central	42,911	.65	46,961	1.88	-	89,872	348.86	1,097,710	763,230,112
NORTHWESTERN REGION:									
Chicago & North Western	136,153	.80	1,591,409	1.22	-	1,727,562	12,698.78	36,834,210	39,993,852,616
Chicago Great Western	177,338	.74	300,327	1.40	-	477,665	1,964.00	5,746,055	9,199,066,008
Chicago, Milwaukee, St.Paul & Pacific	555,885	.64	2,225,492	1.23	-	2,781,377	15,065.94	43,715,374	45,113,476,120
Chicago, St.Paul, Minneapolis & Omaha	273,070	.70	330,345	1.48	-	603,415	2,362.87	7,001,882	7,276,278,864
Duluth, Missabe & Norther.	54,403	.68	140,101	1.96	-	194,504	1,213.65	3,632,305	2,008,108,072
Duluth, South Shore & Atlantic	145,308	.69	114	1.55	-	145,422	678.98	2,032,991	859,769,984
Duluth, Winnipeg & Pacific	69,602	.72	-	-	-	69,602	217.05	651,150	464,258,280
Great Northern	168,780	.52	1,526,407	1.20	* 34,424	1,729,611	10,081.18	32,225,914	28,063,851,128
Green Bay & Western	87,265	.82	-	-	-	87,265	290.81	814,268	398,012,392
Lake Superior & Ishpeming	35,164	.78	-	-	-	35,164	234.39	703,170	131,491,520
Minneapolis & St. Louis	98,920	.87	87,260	1.34	-	186,180	1,816.71	5,462,968	3,867,932,000
Minneapolis, St.Paul & Sault Ste.Marie	401,646	.69	490,521	1.46	-	892,167	5,160.14	15,183,060	10,694,831,160
Northern Pacific	50,503	.55	897,365	1.26	(S) 29	947,897	9,167.83	26,605,617	22,712,810,536
Oregon-Washington R.R.& Nav. Co.	33	.88	219,834	1.01	-	219,867	2,239.67	6,501,045	6,103,139,200
Spokane International	63,308	.54	-	-	-	63,308	194.48	549,518	208,418,880
Spokane, Portland & Seattle	18,766	.53	124,927	1.20	-	143,693	664.66	1,993,980	1,909,066,528

TABLE A

CROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

Sheet 4 of 5

Road	Wooden ties untreated (U) Number	Average Cost	Wooden ties Treated (T) Number	Average Cost	Ties other than wood (S) and second hand re-applied	Total Ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Equated gross ton-miles d
1	2	3	4	5	6	7	8	9	10
CENTRAL WESTERN REGION:									
Alton R.R.	389,971	$ 1.00	5,294	$ 1.68	* 9,983	405,248	1,641.80	4,922,116	7,334,784,568
Atchison, Topeka & Santa Fe	3,249	.78	1,705,304	1.33	-	1,708,553	14,656.52	44,511,851)	65,589,462,576
Panhandle & Santa Fe	-	-	148,309	1.41	-	148,309	2,328.21	6,926,198)	
Chicago, Burlington & Quincy	-	-	1,737,187	1.27	*62,681	1,799,868	12,940.34	39,959,771	43,939,657,888
Chicago, Rock Island & Pacific	a 4,930	.57	a 1,039,037	1.10	-	1,043,967	9,891.11	29,687,971)	39,244,130,616
Chicago, Rock Island & Gulf	-	-	83,741	1.64	* 2,318	86,059	854.07	2,504,177)	
Colorado & Southern	46,055	.43	98,190	1.35	* 2,985	147,230	1,243.21	3,762,115	2,700,738,736
Denver & Rio Grande Western	5,180	.43	559,397	1.18	a 139,188	703,765	3,490.48	10,857,211	9,015,142,304
Denver & Salt Lake	22,044	1.10	20,385	1.37	-	42,429	326.57	979,620	508,077,352
Fort Worth & Denver City	-	-	76,249	1.32	-	76,249	851.52	2,575,904	2,732,147,080
Los Angeles & Salt Lake	2,646	1.17	185,173	1.64	-	187,819	1,519.79	4,216,285	7,404,107,264
Nevada Northern	25,456	.88	-	-	-	25,456	191.23	548,843	99,713,224
Northwestern Pacific	114,781	.73	-	-	-	114,781	547.84	1,614,276	1,022,181,544
Oregon Short Line	1,355	.82	369,336	1.32	-	370,691	3,327.09	9,233,346	10,209,291,304
Quincy, Omaha & Kansas City	-	-	41,831	1.47	* 270	42,101	270.27	821,581	194,240,168
St. Joseph & Grand Island	41,520	1.23	427	1.40	-	41,947	338.32	1,001,767	1,172,999,704
San Diego & Arizona	15,294	1.14	-	-	-	15,294	169.11	498,836	182,410,920
Southern Pacific Co.- Pacific Lines	319,736	.96	1,448,141	1.25	* 2,277	1,770,154	12,904.57	37,846,245	56,247,753,856
Toledo, Peoria & Western	37,518	1.02	8,065	1.37	* 1,800	47,383	274.63	870,028	495,334,216
Union Pacific	260	.96	648,651	1.36	-	648,911	6,009.00	16,962,500	42,557,992,200
Utah Ry.	9,516	.78	7,127	2.01	-	16,643	89.06	231,556	323,522,176
Western Pacific	350,441	.81	-	-	-	350,441	1,342.94	3,949,151	6,316,717,696
SOUTHWESTERN REGION:									
Burlington-Rock Island	-	-	39,725	.99	-	39,725	273.59	857,157	460,136,600
Fort Smith & Western	56,704	.36	-	-	-	56,704	234.90	734,500	321,960,728
Fort Worth & Rio Grande	3,537	.74	25,469	1.38	-	29,006	245.43	777,522	272,539,112
Gulf Coast Lines:									
Beaumont Sour Lake & Western	-	-	16,364	1.28	-	16,364	141.99	422,550)	4,072,349,496
New Orleans, Texas & Mexico	-	-	28,438	1.27	* 197	28,635	224.92	688,172)	
St.Louis, Brownsville & Mexico	-	-	44,771	1.08	* 51	44,822	746.64	2,263,050)	
Gulf, Colorado & Santa Fe	4,458	.41	314,263	1.15	-	318,721	2,550.61	8,258,875	7,171,481,040
International-Great Northern	-	-	253,815	1.14	-	253,815	1,523.42	4,560,300	6,851,890,952
Kansas City Southern	89	.64	169,689	1.12	-	169,778	1,160.72	3,636,520)	4,883,445,144
Texarkana & Fort Smith	-	-	25,089	1.13	-	25,089	161.00	504,350)	
Kansas, Oklahoma & Gulf	844	.46	39,381	1.16	-	40,225	374.21	1,196,601	861,767,768
Louisiana & Arkansas	102,727	.75	82,568	1.06	-	185,295	733.83	2,316,770	1,509,464,328
Louisiana, Arkansas & Texas	24,347	.85	47,313	1.15	-	71,660	232.00	742,400	247,212,720
Midland Valley	2,565	.42	44,767	1.19	-	47,332	422.73	1,357,179	524,802,240
Missouri & North Arkansas	92,014	.52	-	-	-	92,014	384.06	1,138,718	492,549,920

TABLE A

CROSS TIES LAID IN REPLACEMENT - CLASS I STEAM ROADS UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

Sheet 5 of 5

Road	Wooden ties untreated (U) Number	Average Cost	Wooden ties Treated (T) Number	Average Cost	Ties other than wood (S) and second hand re-applied	Total Ties applied	Miles of maintained tracks (item 24)	Estimated total cross ties in all maintained tracks (item 25)	Equated gross ton-miles d
1	2	3	4	5	6	7	8	9	10
SOUTHWESTERN REGION (CONT'D)									
Missouri-Kansas-Texas Lines:									
Missouri-Kansas-Texas	146,815	$ .84	80,917	$ 1.31	-	227,732	2,318.02	7,307,400)	14,443,660,448
Missouri-Kansas-Texas of Texas	85,656	.84	62,726	1.23	-	148,382	1,706.30	5,415,700)	
Missouri Pacific	281,781	.94	1,267,472	1.18	-	1,549,253	9,443.97	29,266,600	41,902,936,808
Oklahoma City-Ada-Atoka	16,494	.61	747	1.32	-	17,241	160.02	483,937	150,445,944
St.Louis-San Francisco	106,764	.60	758,121	1.17	-	864,885	6,970.64	21,643,775	21,105,512,216
St.Louis, San Francisco & Texas	3,798	.61	30,103	1.35	-	33,901	253.95	804,514	402,190,064
St.Louis Southwestern Lines:									
St.Louis Southwestern	17	.47	101,171	1.23	* 916	102,104	1,121.76	3,553,721)	6,579,508,520
St.Louis Southwestern of Texas	-	-	91,885	1.20	*5,342	97,227	970.49	3,054,327)	
San Antonio, Uvalde & Gulf	-	-	82,140	1.28	* 967	83,107	364.26	1,051,228	553,542,896
Texas & New Orleans	165,885	1.13	664,342	1.31	-	830,227	5,982.99	16,351,834	17,509,617,424
Texas & Pacific	611	.59	270,821	1.20	-	271,432	2,537.47	7,478,636	12,550,169,680
Texas Mexican	-	-	38,035	1.18	-	38,035	206.19	593,839	184,153,936
Wichita Falls & Southern	-	-	44,656	1.09	-	44,656	199.07	656,931	138,148,448
Wichita Valley	-	-	46,602	1.26	-	46,602	296.41	888,508	188,976,104
CANADIAN RAILROADS:									
Canadian National	4,783,709	.74	1,804,692	1.52	-	6,588,401	31,334.00	89,497,000	Not reported
Canadian Pacific	1,271,712	.69	3,289,038	1.69	-	4,560,750	21,710.00	62,008,840	Not reported
Temiskaming & Northern Ontario	133,782	.79	-	-	-	133,782	566.57	1,643,050	Not reported

* All second hand ties.
a Includes second hand ties
b All tracks operated less trackage rights.
c Estimated by Bureau of Railway Economics on basis of 2,640 ties to the mile.
d Maischaider formula.
n Indicates narrow gauge ties.

NOTE: Data for U.S. Railroads compiled from Annual Reports of Class I Steam Roads to the Interstate Commerce Commission by Bureau of Railway Economics.

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

NOTE: All figures are exclusive of bridge & switch ties

Sheet 1 of 5

Road	Miles of maintained track occupied by wooden cross-ties (Col.8-table A)	Average number of wooden cross-ties per mile of maintained track	Total number of wooden cross ties renewed 1931	Average number of wooden cross ties renewed per mile of maintained track	Weighted average cost per wooden cross-tie	Average cost of wooden cross tie renewals per mile of maintained track	Average percentage of wooden cross tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND REGION:									
Bangor & Aroostook	849.30	2,877	200,571	236	$ .78	$ 183	8.2	1,800,234	$ .102
Boston & Maine	3,514.81	3,048	578,136	164	1.65	271	5.4	4,404,448	.062
Canadian National Lines in N.E.	255.59	3,075	22,158	87	1.49	129	2.8	1,974,837	.065
Canadian Pacific Lines in Maine	214.05	2,885	56,106	262	1.38	362	9.1	4,824,171	.075
Canadian Pacific Lines in Vermont	123.80	3,367	31,421	254	1.43	362	7.5	4,927,969	.073
Central Vermont	556.89	3,142	131,897	237	1.78	421	7.5	4,414,708	.095
Maine Central	1,371.49	3,033	304,160	222	1.16	257	7.3	2,838,601	.090
New York Connecting	26.30	3,151	7,703	293	1.98	580	9.3	13,211,497	.044
New York, New Haven & Hartford	4,831.43	2,858	796,968	165	1.68	277	5.8	4,568,957	.061
Rutland	525.78	3,002	110,433	210	1.61	337	7.0	3,518,734	.096
GREAT LAKES REGION:									
Ann Arbor	418.47	2,999	47,631	114	1.54	175	3.8	3,480,574	.050
Buffalo, Rochester & Pittsburgh	961.79	2,785	56,416	59	1.79	105	2.1	5,167,412	.020
Delaware & Hudson	1,486.80	3,086	164,947	111	2.40	266	3.6	6,410,784	.042
Delaware, Lackawanna & Western	2,478.38	2,928	187,364	76	1.86	141	2.6	7,114,656	.020
Detroit & Mackinac	303.64	3,000	29,555	97	1.10	107	3.2	907,440	.118
Detroit & Toledo Shore Line	152.14	3,074	12,708	84	2.11	177	2.7	3,614,907	.049
Erie (Including Chicago & Erie)	5,087.28	2,865	881,864	173	1.97	341	6.1	7,437,172	.046
Grand Trunk Western	1,947.93	3,255	303,456	156	1.35	210	4.8	3,608,709	.058
Lehigh & Hudson River	132.23	2,611	7,182	54	1.85	100	2.1	5,532,329	.018
Lehigh & New England	305.06	2,968	32,495	107	1.94	207	3.6	2,818,458	.073
Lehigh Valley	3,126.04	2,963	165,219	53	1.84	97	1.8	5,375,268	.018
Monongahela	250.33	2,880	36,314	145	1.57	228	5.0	3,811,692	.060
Montour	80.10	2,800	13,070	163	1.85	302	5.8	3,925,543	.077
New Jersey & New York	57.05	2,880	8,257	145	1.80	260	5.0	5,575,023	.047
New York Central R.R. Co.	22,979.46	3,108	2,109,362	92	1.78	163	3.0	6,562,853	.025
New York, Chicago & St. Louis	2,809.69	2,986	196,977	70	1.88	132	2.3	5,286,513	.025
New York, Ontario & Western	909.42	2,848	105,579	116	1.69	196	4.1	4,338,935	.045
New York, Susquehanna & Western	238.86	2,886	29,883	125	1.63	204	4.3	2,604,678	.078
Pere Marquette	2,935.79	3,001	559,372	191	1.68	319	6.3	3,212,091	.099
Pittsburgh & Lake Erie	959.62	2,993	3,497	4	1.84	7	0.1	4,318,971	.002
Pittsburg & Shawmut	129.57	2,778	20,592	159	.86	136	5.7	1,740,521	.078
Pittsburgh & West Virginia	202.76	2,900	23,751	117	1.29	151	4.0	2,435,850	.062
Pittsburg, Shawmut & Northern	239.39	2,906	39,471	165	1.27	210	5.7	1,549,479	.135
Ulster & Delaware	158.14	2,733	7,121	45	1.15	52	1.6	1,607,154	.032
Wabash	3,361.00	3,108	400,387	119	1.22	145	3.8	6,322,233	.023

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

NOTE: All figures are exclusive of bridge & switch ties

Sheet 2 of 5

Road	Miles of maintained track occupied by wooden cross ties (Col.8-table A)	Average number of wooden cross ties per mile of maintained track	Total number of wooden cross ties renewed 1931	Average number of wooden cross ties renewed per mile of maintained track	Weighted average cost per wooden cross tie	Average cost of wooden cross tie renewals per mile of maintained track	Average percentage of wooden cross tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
CENTRAL EASTERN REGION:									
Akron, Canton & Youngstown	215.92	2,880	24,890	115	$ 1.84	$ 212	4.0	1,634,942	$ .130
Atlantic City	310.18	2,822	35,302	114	2.02	230	4.0	2,969,856	.077
Baltimore & Ohio	9,766.94	2,850	449,194	46	1.59	73	1.6	5,898,521	.012
Bessemer & Lake Erie	515.11	3,125	122,519	238	1.96	465	7.6	4,515,076	.103
Buffalo & Susquehanna	299.54	2,820	60,371	202	1.42	286	7.1	1,273,007	.225
Central R.R. of New Jersey	1,524.06	2,815	124,618	82	1.84	151	2.9	5,801,906	.026
Chicago & Eastern Illinois	1,545.79	3,101	151,687	98	1.48	145	3.2	3,964,561	.037
Chicago & Illinois Midland	159.82	3,014	16,852	105	1.40	148	3.5	4,350,305	.034
Chicago, Indianapolis & Louisville	888.19	3,079	87,893	99	1.30	128	3.2	4,565,163	.028
Detroit, Toledo & Ironton	643.78	2,880	45,585	71	1.66	117	2.5	2,207,846	.053
Elgin, Joliet & Eastern	915.81	3,088	151,295	165	1.50	248	5.3	2,912,214	.085
Illinois Terminal	729.41	2,705	61,219	84	1.25	105	3.1	1,866,478	.056
Long Island	866.96	2,806	78,717	91	1.84	167	3.2	9,768,000	.017
Missouri-Illinois	245.62	3,099	54,286	221	.69	153	7.1	1,001,286	.153
Pennsylvania R.R.	22,803.98	2,809	1,712,319	75	1.83	138	2.7	7,138,366	.019
Reading Company	3,213.62	2,806	338,767	105	1.79	188	3.8	5,618,529	.034
Staten Island Rapid Transit	103.67	2,746	6,456	62	2.06	128	2.3	-	-
Western Maryland	1,219.23	2,880	227,408	187	1.28	238	6.5	3,988,834	.060
Wheeling & Lake Erie	870.34	3,012	115,996	133	1.52	203	4.4	3,280,824	.062
POCAHONTAS REGION:									
Chesapeake & Ohio (Inc.H.V.)	5,273.07	3,077	669,911	127	1.24	157	4.1	9,166,812	.017
Norfolk & Western	4,412.89	3,100	724,675	164	1.30	214	5.3	7,206,033	.030
Richmond, Fredericksburg & Potomac	379.50	2,863	112,140	295	.97	286	10.3	9,104,072	.031
Virginian	849.31	3,153	198,681	234	1.06	249	7.4	6,292,310	.040
SOUTHERN REGION:									
Alabama Great Southern	551.54	3,086	189,287	343	1.43	491	11.1	4,549,169	.108
Atlanta & West Point	b 166.84	2,640	26,733	160	1.42	228	6.1	3,208,940	.074
Western Ry. of Alabama	b 212.54	2,640	36,326	171	1.43	244	6.5		
Atlanta, Birmingham & Coast	799.64	2,877	177,635	222	1.14	253	7.7	1,924,252	.132
Atlantic Coast Line	6,880.27	2,905	1,443,136	210	1.01	214	7.2	3,072,358	.070
Central of Georgia	2,559.67	2,790	365,623	143	.84	120	5.1	2,859,201	.042
Charleston & Western Carolina	427.27	2,772	101,315	237	1.08	256	8.6	1,871,589	.137
Cincinnati, New Orleans & Texas Pacific	780.09	3,093	218,982	281	1.54	432	9.1	7,991,154	.054
Clinchfield	401.94	3,040	160,562	399	.99	394	13.1	5,039,380	.078
Columbus & Greenville	205.28	3,168	31,219	152	1.12	171	4.8	1,491,409	.115
Florida East Coast	1,526.77	2,871	51,836	34	.96	32	1.2	2,347,467	.014
Georgia R.R.	439.46	2,952	105,353	240	1.36	326	8.1	3,518,332	.093
Georgia & Florida	511.92	2,706	131,167	256	.64	163	9.5	820,047	.199
Georgia, Southern & Florida	472.81	3,117	121,245	256	1.03	263	8.2	2,849,911	.092

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

NOTE: All figures are exclusive of bridge & switch ties

Sheet 3 of 5

Road	Miles of maintained track occupied by wooden cross ties (Col.8-table A)	Average number of wooden cross ties per mile of maintained track	Total number of wooden cross ties renewed 1931	Average number of wooden cross ties renewed per mile of maintained track	Weighted average cost per wooden cross tie	Average cost of wooden cross tie renewals per mile of maintained track	Average percentage of wooden cross tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
SOUTHERN REGION (CONT'D)									
Gulf & Ship Island	366.90	3,085	105,531	288	$ 1.02	$ 292	9.3	1,467,480	$ .199
Gulf, Mobile & Northern	681.30	3,200	99,937	147	1.04	153	4.6	2,334,768	.066
Illinois Central	7,990.44	3,049	1,324,020	166	1.14	190	5.4)	4,982,602	.042
Yazoo & Mississippi Valley	2,213.08	3,059	522,546	236	1.21	285	7.7)		
Louisville & Nashville	7,262.65	2,912	1,223,058	168	1.62	273	5.8	4,885,092	.056
Mississippi Central	170.19	3,150	28,460	167	1.02	171	5.3	1,331,239	.129
Mobile & Ohio	1,285.05	3,168	369,071	287	.71	204	9.1	3,248,978	.063
Nashville, Chattanooga & St.Louis	1,579.21	2,971	504,178	319	1.29	412	10.7	3,888,164	.106
New Orleans & Northeastern	289.40	3,085	71,800	248	1.43	354	8.0	4,795,877	.074
New Orleans Great Northern	291.56	3,200	38,569	132	1.03	136	4.1	1,943,443	.070
Norfolk Southern	1,093.85	2,848	249,933	228	.74	169	8.0	1,627,914	.104
Northern Alabama	138.61	3,166	48,689	351	.86	301	11.1	1,459,700	.206
Seaboard Air Line	5,707.89	3,106	1,474,257	258	.92	238	8.3	3,062,613	.078
Southern Ry.	8,961.17	3,177	3,012,247	336	1.06	358	10.6	4,193,165	.085
Tennessee Central	348.86	3,147	89,872	258	1.29	333	8.2	2,187,783	.152
NORTHWESTERN REGION:									
Chicago & North Western	12,698.78	2,901	1,727,562	136	1.19	162	4.7	3,149,425	.051
Chicago Great Western	1,964.00	2,926	477,665	243	1.15	281	8.3	4,683,842	.060
Chicago, Milwaukee, St.Paul & Pacific	15,065.94	2,902	2,781,377	185	1.11	205	6.4	2,994,402	.068
Chicago, St.Paul, Minneapolis & Omaha	2,362.87	2,963	603,415	255	1.13	287	8.6	3,079,424	.093
Duluth, Missabe & Northern	1,213.65	2,993	194,504	160	1.60	257	5.4	1,654,602	.155
Duluth, South Shore & Atlantic	678.98	2,994	145,422	214	.69	148	7.2	1,266,267	.117
Duluth, Winnipeg & Pacific	217.05	3,000	69,602	321	.72	230	10.7	2,138,946	.107
Great Northern	10,081.18	3,197	1,695,187	168	1.13	190	5.3	2,783,786	.068
Green Bay & Western	290.81	2,800	87,265	300	.82	245	10.7	1,368,634	.179
Lake Superior & Ishpeming	234.39	3,000	35,164	150	.78	117	5.0	560,995	.208
Minneapolis & St. Louis	1,816.71	3,007	186,180	102	1.09	112	3.4	2,129,086	.053
Minneapolis, St.Paul & Sault Ste.Marie	5,160.14	2,942	892,167	173	1.12	193	5.9	2,072,585	.093
Northern Pacific	9,167.83	2,902	947,868	103	1.22	127	3.6	2,477,447	.051
Oregon-Washington R.R. & Nav. Co.	2,239.67	2,903	219,867	98	1.01	99	3.4	2,725,017	.036
Spokane International	194.48	2,826	63,308	326	.54	175	11.5	1,071,673	.163
Spokane, Portland & Seattle	664.66	3,000	143,693	216	1.11	239	7.2	2,872,245	.083
CENTRAL WESTERN REGION:									
Alton R.R.	1,641.80	2,998	395,265	241	1.01	243	8.0	4,467,526	.054
Atchison, Topeka & Santa Fe	14,656.52	3,037	1,708,553	117	1.33	155	3.8)	3,861,672	.038
Panhandle & Santa Fe	2,328.21	2,975	148,309	64	1.41	90	2.1)		
Chicago, Burlington & Quincy	12,940.34	3,088	1,737,187	134	1.27	170	4.3	3,395,557	.050
Chicago, Rock Island & Pacific	9,891.11	3,001	1,043,967	106	1.10	116	3.5)	3,652,254	.033
Chicago, Rock Island & Gulf	854.07	2,932	83,741	98	1.64	161	3.3)		

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

NOTE: All figures are exclusive of bridge & switch ties

Sheet 4 of 5

Road	Miles of maintained track occupied by wooden cross ties (Col.8-table A)	Average number of wooden cross ties per mile of maintained track	Total number of wooden cross ties renewed 1931	Average number of wooden cross ties renewed per mile of maintained track	Weighted average cost per wooden cross tie	Average cost of wooden cross tie renewals per mile of maintained track	Average percentage of wooden cross tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
CENTRAL WESTERN REGION (CONT'D)									
Colorado & Southern	1,243.21	3,026	144,245	116	$ 1.05	$ 122	3.8	2,172,391	$ .056
Denver & Rio Grande Western	3,490.48	3,111	564,577	162	1.18	190	5.2	2,582,780	.074
Denver & Salt Lake	326.57	3,000	42,429	130	1.23	160	4.3	1,555,799	.103
Fort Worth & Denver City	851.52	3,025	76,249	90	1.32	118	3.0	3,208,553	.037
Los Angeles & Salt Lake	1,519.79	2,774	187,819	124	1.63	202	4.5	4,871,796	.041
Nevada Northern	191.23	2,870	25,456	133	.88	117	4.6	521,431	.223
Northwestern Pacific	547.84	2,947	114,781	210	.73	153	7.1	1,865,840	.082
Oregon Short Line	3,327.09	2,775	370,691	111	1.32	147	4.0	3,068,535	.048
Quincy, Omaha & Kansas City	270.27	3,040	41,831	155	1.47	228	5.1	718,689	.317
St. Joseph & Grand Island	338.32	2,961	41,947	124	1.23	152	4.2	3,467,131	.044
San Diego & Arizona	169.11	2,950	15,294	90	1.14	103	3.1	1,078,652	.096
Southern Pacific Co.- Pacific Lines	12,904.57	2,933	1,767,877	137	1.20	164	4.7	4,358,747	.038
Toledo, Peoria & Western	274.63	3,168	45,583	166	1.08	179	5.2	1,803,642	.099
Union Pacific	6,009.00	2,823	648,911	108	1.36	147	3.8	7,082,375	.021
Utah Ry.	89.06	2,600	16,643	187	1.31	244	7.2	3,632,632	.067
Western Pacific	1,342.94	2,941	350,441	261	.81	211	8.9	4,703,648	.045
SOUTHWESTERN REGION:									
Burlington-Rock Island	273.59	3,133	39,725	145	.99	144	4.6	1,681,847	.086
Fort Smith & Western	234.90	3,127	56,704	241	.36	87	7.7	1,370,629	.064
Fort Worth & Rio Grande	245.43	3,168	29,006	118	1.30	154	3.7	1,110,456	.138
Gulf Coast Lines:									
Beaumont, Sour Lake & Western	141.99	2,976	16,364	115	1.28	147	3.9		
New Orleans, Texas & Mexico	224.92	3,060	28,438	126	1.27	161	4.1	3,657,087	.026
St.Louis, Brownsville & Mexico	746.64	3,031	44,771	60	1.08	65	2.0		
Gulf, Colorado & Santa Fe	2,550.61	3,238	318,721	125	1.14	142	3.9	2,811,673	.051
International-Great Northern	1,523.42	2,993	253,815	167	1.14	190	5.6	4,497,703	.042
Kansas City Southern	1,160.72	3,133	169,778	146	1.12	164	4.7	3,694,765	.045
Texarkana & Fort Smith	161.00	3,133	25,089	156	1.13	175	5.0		
Kansas, Oklahoma & Gulf	374.21	3,198	40,225	107	1.15	123	3.4	2,302,899	.053
Louisiana & Arkansas	733.83	3,157	185,295	253	.89	224	8.0	2,056,967	.109
Louisiana, Arkansas & Texas	232.00	3,200	71,660	309	1.05	324	9.7	1,065,572	.304
Midland Valley	422.73	3,211	47,332	112	1.15	128	3.5	1,241,460	.103
Missouri & North Arkansas	384.06	2,965	92,014	240	.52	124	8.1	1,282,482	.097
Missouri-Kansas-Texas Lines:									
Missouri-Kansas-Texas	2,318.02	3,152	227,732	98	1.01	99	3.1	3,589,093	.026
Missouri-Kansas-Texas of Texas	1,706.30	3,174	148,382	87	1.01	88	2.7		
Missouri Pacific	9,443.97	3,099	1,549,253	164	1.14	186	5.3	4,437,004	.042
Oklahoma City-Ada-Atoka	160.02	3,024	17,241	108	.64	69	3.6	940,170	.074

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES AND CANADIAN ROADS

Calendar Year Ended December 31, 1931

NOTE: All figures are exclusive of bridge & switch ties

Sheet 5 of 5

Road	Miles of maintained track occupied by wooden cross ties (Col.8-table A)	Average number of wooden cross ties per mile of maintained track	Total number of wooden cross ties renewed 1931	Average number of wooden cross ties renewed per mile of maintained track	Weighted average cost per wooden cross tie	Average cost of wooden cross tie renewals per mile of maintained track	Average percentage of wooden cross tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
SOUTHWESTERN REGION (CONT'D)									
St.Louis-San Francisco	6,970.64	3,105	864,885	124	$ 1.10	$ 137	4.0	3,027,773	$ .045
St.Louis, San Francisco & Texas	253.95	3,168	33,901	133	1.27	170	4.2	1,583,737	.107
St.Louis Southwestern Lines:									
St.Louis Southwestern	1,121.76	3,168	101,188	90	1.23	111	2.8)	3,144,705	.036
St.Louis Southwestern of Texas	970.49	3,147	91,885	95	1.20	114	3.0)		
San Antonio, Uvalde & Gulf	364.26	2,886	82,140	225	1.28	288	7.8	1,519,637	.190
Texas & New Orleans	5,982.99	2,733	830,227	139	1.27	176	5.1	2,926,566	.060
Texas & Pacific	2,537.47	2,947	271,432	107	1.20	128	3.6	4,945,938	.026
Texas Mexican	206.19	2,860	38,035	184	1.18	218	6.4	893,127	.244
Wichita Falls & Southern	199.07	3,300	44,656	224	1.09	245	6.8	693,969	.353
Wichita Valley	296.41	2,998	46,602	157	1.26	199	5.2	637,550	.312
CANADIAN RAILROADS:									
Canadian National	31,334.00	2,856	6,588,401	210	.95	200	7.3	Not reported	
Canadian Pacific	21,710.00	2,856	4,560,750	210	1.41	297	7.3	Not reported	
Temiskaming & Northern Ontario	566.57	2,900	133,782	236	.79	186	8.1	Not reported	

Col. 3 derived by dividing Col.9 Table A by Col.8 of same table.
Col. 4 is total of columns 2 and 4 of Table A.
Col. 5 derived by dividing the totals of Columns 2 and 4 of table A by Col.8 of same table.
Col. 6 is weighted average of costs shown in columns 3 and 5 of table A.
b All tracks operated less trackage rights.
NOTE: Data for U.S. Railroads compiled from Annual Reports of Class I Steam Roads to the Interstate Commerce Commission by Bureau of Railway Economics.

TABLE C

AVERAGE NUMBER AND AVERAGE COST OF WOODEN CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF WOODEN CROSS TIE RENEWALS TO TOTAL WOODEN CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and Canada, by years, and for the average of the five years 1927 to 1931 inclusive

NOTE: All figures are exclusive of bridge and switch ties

Sheet 1 of 5

Road	Average number of wooden cross tie renewals per mile of maintained track						Average cost of wooden cross tie renewals per mile of maintained track						Average percentage of wooden cross tie renewals					
	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average
NEW ENGLAND REGION:																		
Bangor & Aroostook	194	230	255	253	236	234	$144	$179	$212	$207	$183	$185	6.7	8.3	8.8	8.8	8.2	8.2
Boston & Maine	267	277	240	236	164	242	425	468	426	385	271	397	9.9	9.9	9.1	8.7	5.4	8.6
Canadian National Lines in N.E.	222	199	235	160	87	180	371	368	383	251	129	299	7.5	6.3	7.4	5.0	2.8	5.8
Canadian Pacific Lines in Maine	292	330	311	320	262	303	383	426	395	397	362	391	10.7	11.4	10.8	11.1	9.1	10.6
Canadian Pacific Lines in Vermont	298	518	326	313	254	340	381	637	385	413	362	435	10.4	16.2	10.6	10.0	7.5	10.9
Central Vermont	307	312	249	244	237	270	500	549	453	427	421	470	9.6	9.7	7.8	7.6	7.5	8.5
Maine Central	254	229	204	244	222	231	277	254	224	273	257	259	8.4	7.5	6.7	8.0	7.3	7.6
New York Connecting	62	73	238	194	293	172	130	153	488	382	580	346	1.9	2.3	7.4	6.1	9.3	5.4
New York, New Haven & Hartford	332	328	267	253	165	267	551	558	486	412	277	454	11.1	9.8	8.6	8.2	5.8	8.7
Rutland	290	282	270	224	210	255	493	485	459	365	337	428	9.6	9.4	9.3	7.5	7.0	8.6
GREAT LAKES REGION:																		
Ann Arbor	237	242	202	148	114	188	372	397	339	226	175	301	7.9	8.1	6.7	4.9	3.8	6.3
Buffalo, Rochester & Pittsburgh	116	136	106	106	59	105	239	261	226	204	105	208	4.7	4.9	3.8	3.8	2.1	3.9
Delaware & Hudson	209	127	201	172	111	164	464	305	519	432	266	397	7.5	4.5	6.7	5.7	3.6	5.6
Delaware, Lackawanna & Western	104	98	84	80	76	89	176	184	159	151	141	163	3.6	3.4	2.9	2.8	2.6	3.1
Detroit & Mackinac	195	232	164	202	97	181	218	295	162	194	107	199	6.4	7.5	5.5	6.7	3.2	6.0
Detroit & Toledo Shore Line	191	163	132	112	84	135	384	319	269	235	177	274	5.9	5.2	4.2	3.6	2.7	4.3
Erie (Including Chicago & Erie)	211	210	221	199	173	203	411	443	480	422	341	420	7.8	8.1	8.2	7.0	6.1	7.4
Grand Trunk Western (See note)	314	347	303	191	156	254	414	486	400	252	210	340	9.8	10.4	9.4	5.9	4.8	7.8
Lehigh & Hudson River	80	51	49	66	54	60	156	83	80	127	100	109	3.1	1.9	1.9	2.5	2.1	2.3
Lehigh & New England	114	118	132	121	107	118	192	238	257	243	207	227	4.1	4.2	4.5	4.1	3.6	4.1
Lehigh Valley	92	65	74	64	53	70	175	131	147	118	97	134	3.4	2.2	2.5	2.2	1.8	2.4
Monongahela	228	277	202	215	145	213	381	493	347	368	228	362	7.5	9.1	6.9	7.6	5.0	7.2
Montour	322	307	306	259	163	270	770	706	655	552	302	591	11.2	10.9	10.8	9.2	5.8	9.6
New Jersey & New York	151	195	124	167	145	156	325	390	258	319	260	309	5.9	5.8	4.8	5.8	5.0	5.5
New York Central R.R.Co. (See note)	136	138	130	111	92	122	276	265	251	208	163	234	4.5	4.4	4.2	3.6	3.0	3.9
New York, Chicago & St. Louis	204	169	169	135	70	148	404	331	330	254	132	287	6.5	5.5	5.2	4.2	2.3	4.7
New York, Ontario & Western	158	174	134	119	116	140	289	331	244	206	196	253	5.8	6.1	4.7	4.2	4.1	5.0
New York, Susquehanna & Western	218	218	205	174	125	188	371	401	404	322	204	340	8.5	8.3	8.0	6.0	4.3	7.0
Pere Marquette	207	227	213	168	191	200	275	329	302	294	319	304	6.9	7.6	7.1	6.4	6.3	6.8
Pittsburgh & Lake Erie	100	91	73	62	4	67	235	220	165	151	7	158	3.4	3.6	2.5	2.1	0.1	2.3
Pittsburgh & Shawmut	315	319	322	158	159	256	350	357	361	188	136	279	12.7	a	11.6	5.7	5.7	9.5
Pittsburgh & West Virginia	108	93	182	108	117	121	188	161	297	176	151	191	4.0	3.2	6.3	3.7	4.0	4.2
Pittsburgh, Shawmut & Northern	288	264	243	185	165	229	389	312	401	333	210	327	10.3	9.4	8.7	6.4	5.7	8.1
Ulster & Delaware	96	63	57	63	45	65	164	86	81	89	52	95	3.6	2.3	2.1	2.3	1.6	2.4
Wabash	217	238	221	177	119	195	339	374	347	253	145	293	7.4	7.6	7.0	5.6	3.8	6.3

TABLE C

AVERAGE NUMBER AND AVERAGE COST OF WOODEN CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF WOODEN CROSS TIE RENEWALS TO TOTAL WOODEN CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and Canada, by years, and for the average of the five years 1927 to 1931 inclusive

NOTE: All figures are exclusive of bridge and switch ties

Sheet 2 of 5

Road	Average number of wooden cross tie renewals per mile of maintained track						Average cost of wooden cross tie renewals per mile of maintained track						Average percentage of wooden cross tie renewals					
	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average
CENTRAL EASTERN REGION:																		
Akron, Canton & Youngstown	344	375	363	280	115	289	$461	$536	$581	$445	$212	$445	11.4	11.8	12.6	8.7	4.0	9.7
Atlantic City	110	98	104	109	114	107	257	221	212	230	230	230	3.8	3.4	3.6	3.9	4.0	3.7
Baltimore & Ohio	177	166	155	182	46	135	283	294	260	201	73	225	6.8	6.4	6.0	4.3	1.6	5.0
Bessemer & Lake Erie	211	224	227	231	238	226	397	455	472	508	465	459	7.2	7.1	7.2	7.3	7.6	7.3
Buffalo & Susquehanna	199	224	224	224	202	214	299	320	305	325	286	306	7.1	7.9	7.9	7.9	7.1	7.6
Central R.R. of New Jersey	69	85	79	83	82	79	137	176	164	156	151	156	3.1	3.2	2.8	2.9	2.9	3.0
Chicago & Eastern Illinois	119	132	119	101	98	114	184	211	181	152	145	174	4.0	4.0	4.0	3.2	3.2	3.7
Chicago & Illinois Midland	299	268	223	126	105	203	484	351	343	202	148	311	10.4	9.4	7.8	4.2	3.5	7.0
Chicago, Indianapolis & Louisville	111	130	132	156	99	125	150	177	180	207	128	168	3.9	4.2	4.3	5.1	3.2	4.1
Detroit, Toledo & Ironton	147	113	164	149	71	129	281	211	325	244	117	236	5.1	4.0	5.7	5.2	2.5	4.5
Elgin, Joliet & Eastern	262	280	269	226	165	239	359	395	385	353	248	347	8.4	9.1	8.7	7.3	5.3	7.7
Illinois Terminal	b	114	77	94	84	92	b	164	115	130	105	128	b	3.8	2.9	3.5	3.1	3.3
Long Island	191	224	193	129	91	166	392	450	392	241	167	330	8.0	8.0	6.9	4.6	3.2	6.1
Missouri-Illinois	c	c	260	197	221	226	c	c	187	201	153	181	c	c	9.0	6.4	7.1	7.5
Pennsylvania R.R. (See note)	167	167	159	124	75	139	334	331	312	227	138	270	6.7	6.1	5.8	4.4	2.7	5.1
Reading Company (See note)	176	156	148	137	105	144	347	309	289	247	188	275	6.1	5.4	5.2	4.8	3.8	5.0
Staten Island Rapid Transit	96	113	76	73	62	84	170	251	142	147	128	167	3.8	4.1	2.8	2.6	2.3	3.1
Western Maryland	347	378	256	206	187	273	437	567	389	274	238	379	12.0	13.1	8.9	7.1	6.5	9.5
Wheeling & Lake Erie	279	307	267	171	133	232	463	522	446	258	203	380	9.7	10.2	8.9	5.7	4.4	7.8
POCAHONTAS REGION:																		
Chesapeake & Ohio (See note)	311	251	211	173	127	212	435	351	283	239	157	288	10.1	8.4	7.1	5.6	4.1	7.0
Norfolk & Western	232	223	203	176	164	200	327	357	311	248	214	292	7.6	7.0	6.6	5.7	5.3	6.4
Richmond, Fredericksburg & Potomac	363	326	424	401	295	362	432	378	471	457	286	405	14.1	11.4	14.8	14.0	10.3	12.9
Virginian	325	359	355	342	234	323	371	402	387	373	249	355	11.5	11.4	11.3	10.9	7.4	10.5
SOUTHERN REGION:																		
Alabama Great Southern	573	456	409	342	343	419	722	570	515	469	491	549	15.3	14.8	13.3	11.1	11.1	13.0
Atlanta & West Point	206	207	190	198	160	191	288	282	255	255	228	260	6.5	6.5	7.2	7.5	6.1	6.7
Western Ry. of Alabama	276	356	231	268	171	257	408	506	305	346	244	357	9.0	11.4	7.7	8.9	6.5	8.7
Atlanta, Birmingham & Coast	377	332	303	243	222	295	434	372	324	277	253	330	13.1	11.5	10.4	8.4	7.7	10.2
Atlantic Coast Line	228	224	234	218	210	223	255	253	262	238	214	245	8.3	7.7	8.1	7.5	7.2	7.8
Central of Georgia	205	191	204	144	143	178	199	193	190	131	120	167	10.6	6.9	7.3	5.2	5.1	6.8
Charleston & Western Carolina	295	300	310	275	237	283	322	318	372	327	256	320	10.6	10.3	10.7	9.9	8.6	10.0
Cincinnati, New Orleans & Texas Pacific	458	441	394	300	281	372	577	657	595	447	432	539	14.9	14.3	12.8	9.7	9.1	12.0
Clinchfield	413	407	476	477	399	434	396	387	471	425	394	412	13.6	13.4	15.6	15.7	13.1	14.3
Columbus & Greenville	578	540	447	415	152	426	699	702	554	519	171	528	18.2	17.0	14.1	13.1	4.8	13.4
Florida East Coast	108	95	62	36	34	67	141	152	106	40	32	94	4.1	3.6	2.2	1.2	1.2	2.4
Georgia R.R.	316	226	286	250	240	263	436	307	395	335	326	360	10.2	7.3	9.6	8.3	8.1	8.7
Georgia & Florida	239	191	182	216	256	217	177	111	137	157	163	150	9.0	7.5	6.8	8.0	9.5	8.2
Georgia, Southern & Florida	306	346	367	247	256	305	459	401	396	259	263	357	9.1	10.5	11.7	7.9	8.2	9.5

TABLE C

AVERAGE NUMBER AND AVERAGE COST OF WOODEN CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF WOODEN CROSS TIE RENEWALS TO TOTAL WOODEN CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and Canada, by years, and for the average of the five years 1927 to 1931 inclusive

NOTE: All figures are exclusive of bridge and switch ties

Sheet 3 of 5

Road	Average number of wooden cross tie renewals per mile of maintained track						Average cost of wooden cross tie renewals per mile of maintained track						Average percentage of wooden cross tie renewals					
	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average
SOUTHERN REGION (CONT'D)																		
Gulf & Ship Island	355	248	359	320	288	314	$444	$315	$445	$352	$292	$371	12.3	8.0	11.5	10.4	9.3	10.3
Gulf, Mobile & Northern	193	199	210	213	147	193	212	207	214	215	153	201	6.4	6.6	7.0	6.7	4.6	6.2
Illinois Central	161	179	188	161	166	171	196	222	214	187	190	202	5.6	5.8	6.1	5.3	5.4	5.7
Yazoo & Mississippi Valley	254	278	298	237	236	260	328	367	361	294	285	328	8.7	9.1	9.7	7.6	7.7	8.5
Louisville & Nashville (See note)	228	240	235	200	168	215	369	410	376	314	273	350	8.1	8.3	8.2	7.2	5.8	7.5
Mississippi Central	191	157	197	204	167	183	214	177	225	237	171	205	6.4	5.0	6.3	6.5	5.3	5.9
Mobile & Ohio	376	363	368	361	287	351	365	334	339	318	204	312	12.5	11.4	11.6	11.4	9.1	11.2
Nashville, Chattanooga & St. Louis	319	279	250	296	319	293	405	365	333	403	412	384	11.6	9.4	8.4	10.0	10.7	10.1
New Orleans & Northeastern	376	420	337	273	248	332	511	538	438	349	354	442	13.6	13.6	10.9	8.9	8.0	11.0
New Orleans Great Northern	256	207	300	234	132	225	320	238	342	239	136	254	7.8	6.3	9.2	7.3	4.1	6.9
Norfolk Southern	277	248	283	306	228	268	235	208	241	269	169	225	10.4	9.3	10.1	10.8	8.0	9.7
Northern Alabama	499	645	437	385	351	462	454	568	415	381	301	425	15.9	20.2	13.8	12.2	11.1	14.6
Seaboard Air Line	244	241	251	227	258	244	283	229	254	227	238	246	8.0	7.8	8.1	7.3	8.3	7.9
Southern Ry.	388	391	392	351	336	372	462	454	435	386	358	420	12.2	12.3	12.4	11.1	10.6	11.7
Tennessee Central	467	441	435	310	258	383	327	423	457	341	333	375	15.1	14.2	14.0	10.0	8.2	12.3
NORTHWESTERN REGION:																		
Chicago & North Western	204	198	183	173	136	179	249	244	218	202	162	215	6.9	6.9	6.4	6.0	4.7	6.2
Chicago Great Western	221	211	205	220	243	220	252	241	219	255	281	249	7.7	7.3	7.1	7.5	8.3	7.6
Chicago, Milwaukee, St. Paul & Pacific	285	302	287	214	185	255	285	311	307	231	205	268	10.2	10.4	9.9	7.4	6.4	8.9
Chicago, St. Paul, Minneapolis & Omaha	265	330	282	223	255	272	313	389	341	263	287	321	9.7	11.9	9.5	7.5	8.6	9.4
Duluth, Missabe & Northern (See note)	261	239	225	174	160	212	407	392	389	289	257	348	8.4	7.7	7.3	5.8	5.4	6.9
Duluth, South Shore & Atlantic	340	323	272	235	214	278	238	249	207	179	148	206	11.7	10.8	9.1	7.9	7.2	9.3
Duluth, Winnipeg & Pacific	435	426	386	266	321	366	291	294	282	202	230	260	14.9	14.2	12.9	8.9	10.7	12.3
Great Northern	206	220	205	190	168	198	210	260	254	224	190	228	6.6	7.0	6.4	6.0	5.3	6.3
Green Bay & Western	331	297	322	296	300	309	261	261	287	258	245	263	11.9	10.7	11.5	10.6	10.7	11.1
Lake Superior & Ishpeming	219	236	250	230	150	217	142	170	178	166	117	154	7.3	7.9	8.3	7.7	5.0	7.2
Minneapolis & St. Louis	218	203	150	122	102	159	279	262	173	139	112	192	7.2	6.7	5.0	4.0	3.4	5.3
Minneapolis, St. Paul & Sault Ste. Marie	270	271	238	222	173	235	232	263	259	271	193	244	9.2	9.2	8.1	7.5	5.9	8.0
Northern Pacific	158	180	169	124	103	147	177	220	208	156	127	178	5.8	6.2	5.8	4.3	3.6	5.1
Oregon-Washington R.R. & Nav. Co.	254	227	198	167	98	189	208	193	172	164	99	168	8.7	7.9	6.9	5.7	3.4	6.5
Spokane International	346	363	356	348	326	348	180	203	196	195	175	191	12.7	12.9	12.6	12.4	11.5	12.4
Spokane, Portland & Seattle	318	328	356	294	216	302	273	364	424	385	239	335	11.0	11.4	12.3	10.2	7.2	10.4
CENTRAL WESTERN REGION:																		
Alton R.R.	275	287	218	254	241	255	330	348	253	284	243	291	9.2	9.6	7.3	9.0	8.0	8.6
Atchison, Topeka & Santa Fe (See note)	146	180	176	160	117	156	210	265	253	221	155	222	2.5	3.1	5.8	5.3	3.8	3.7
Panhandle & Santa Fe (See note)	331	299	146	140	64	188	364	389	223	199	90	244	11.4	10.5	4.9	4.7	2.1	6.4
Chicago, Burlington & Quincy	166	170	168	151	134	158	217	223	218	195	170	205	5.4	5.5	5.4	4.9	4.3	5.1
Chicago, Rock Island & Pacific	148	150	156	128	106	138	172	180	173	141	116	157	5.1	5.0	5.2	4.3	3.5	4.6
Chicago, Rock Island & Gulf	268	206	184	185	98	181	354	284	254	296	161	262	8.8	7.5	6.6	6.1	3.3	6.2

TABLE C

AVERAGE NUMBER AND AVERAGE COST OF WOODEN CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF WOODEN CROSS TIE RENEWALS TO TOTAL WOODEN CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and Canada, by years, and for the average of the five years 1927 to 1931 inclusive

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Sheet 4 of 5

Road	Average number of wooden cross tie renewals per mile of maintained track						Average cost of wooden cross tie renewals per mile of maintained track						Average percentage of wooden cross tie renewals					
	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average
CENTRAL WESTERN REGION (CONT'D)																		
Colorado & Southern	193	168	156	140	116	155	$270	$225	$181	$153	$122	$191	6.4	5.6	5.2	4.6	3.8	5.1
Denver & Rio Grande Western	219	303	198	175	162	211	254	318	234	210	190	241	7.4	9.7	6.4	5.6	5.2	6.8
Denver& Salt Lake	308	214	158	138	130	189	456	280	202	168	160	251	10.3	7.1	5.3	4.6	4.3	6.3
Fort Worth & Denver City	301	267	212	178	90	201	445	382	284	240	118	279	10.2	8.5	7.0	5.9	3.0	6.6
Los Angeles & Salt Lake	145	162	167	132	124	145	197	236	252	215	202	219	5.2	5.8	6.0	4.7	4.5	5.2
Nevada Northern	203	193	183	169	133	176	208	197	179	162	117	172	7.0	6.7	6.4	5.9	4.6	6.1
Northwestern Pacific	247	278	294	270	210	260	200	220	226	205	153	200	8.3	9.4	10.0	9.2	7.1	8.8
Oregon Short Line	200	176	177	151	111	163	230	209	216	198	147	200	7.2	6.3	6.4	5.4	4.0	5.9
Quincy, Omaha & Kansas City	255	251	189	192	155	208	344	331	276	280	228	291	8.1	8.0	6.0	6.1	5.1	6.7
St.Joseph & Grand Island	219	221	183	126	124	174	318	292	232	169	152	231	7.8	7.4	6.2	4.2	4.2	5.9
San Diego & Arizona	b	113	114	132	90	113	b	134	184	160	103	131	b	3.8	3.9	4.5	3.1	3.8
Southern Pacific Co.- Pacific Lines	225	210	202	164	137	187	324	300	261	198	164	249	7.7	7.2	6.9	5.6	4.7	6.4
Toledo, Peoria & Western	294	176	247	155	166	208	359	224	309	189	179	252	9.8	5.6	7.8	4.9	5.2	6.6
Union Pacific	200	192	162	123	108	157	234	221	206	169	147	195	7.1	6.8	5.8	4.3	3.8	5.6
Utah Ry.	104	196	201	234	187	180	126	282	267	321	244	241	3.6	6.7	7.7	9.0	7.2	6.6
Western Pacific	411	424	426	338	261	372	349	352	337	281	211	305	14.5	14.9	14.9	11.6	8.9	12.9
SOUTHWESTERN REGION:																		
Burlington-Rock Island	193	284	246	400	145	259	201	301	244	328	144	264	6.2	9.1	7.9	12.8	4.6	8.3
Fort Smith & Western	311	316	342	311	241	304	221	199	229	202	87	188	9.9	10.1	10.9	9.9	7.7	9.7
Fort Worth & Rio Grande	279	308	426	153	118	257	318	394	554	207	154	326	8.8	9.7	13.5	4.8	3.7	8.1
Gulf Coast Lines:																		
Beaumont, Sour Lake & Western	290	238	219	216	115	212	394	326	276	281	147	280	9.7	8.0	7.4	7.3	3.9	7.1
New Orleans, Texas & Mexico	300	280	240	224	126	234	402	381	302	293	161	309	9.8	9.2	7.8	7.3	4.1	7.6
St.Louis, Brownsville & Mexico	401	315	184	158	60	221	505	406	213	172	65	270	13.1	10.3	6.1	5.2	2.0	7.3
Gulf, Colorado & Santa Fe	130	139	205	191	125	158	172	172	260	227	142	194	3.7	4.3	6.3	5.9	3.9	4.8
International-Great Northern	270	281	214	204	167	227	319	346	268	235	190	270	9.4	9.4	7.1	6.8	5.6	7.6
Kansas City Southern	142	162	157	169	146	155	200	235	207	204	164	202	4.5	5.2	5.0	5.4	4.7	4.9
Texarkana & Fort Smith	90	94	117	140	156	120	173	167	195	168	175	176	2.9	3.0	3.7	4.5	5.0	3.9
Kansas, Oklahoma & Gulf	573	377	112	117	107	256	894	675	166	164	123	402	18.2	12.0	3.5	3.7	3.4	8.0
Louisiana & Arkansas (See note)	255	323	303	339	253	294	252	336	324	322	224	291	8.2	10.2	9.5	10.7	8.0	9.3
Louisiana, Arkansas & Texas	262	443	330	374	309	342	252	399	304	344	324	325	8.7	13.8	10.3	11.7	9.7	10.8
Midland Valley	282	240	208	165	112	202	409	391	306	224	128	293	9.1	7.7	6.5	5.1	3.5	6.4
Missouri & North Arkansas	390	263	326	250	240	294	269	168	245	175	124	197	13.1	8.4	11.0	8.0	8.1	9.7
Missouri-Kansas-Texas Lines:																		
Missouri-Kansas-Texas	250	214	201	168	98	187	320	272	263	223	99	237	8.5	6.8	6.4	5.3	3.1	6.0
Missouri-Kansas-Texas of Texas	229	265	234	152	87	192	295	334	307	202	88	244	7.8	8.3	7.4	4.8	2.7	6.1
Missouri Pacific	267	280	294	217	164	244	283	302	303	232	186	261	9.3	9.0	9.5	7.0	5.3	8.0
Oklahoma City-Ada-Atoka	d	d	d	404	108	254	d	d	d	347	69	206	d	d	d	12.9	3.6	8.2

TABLE C

AVERAGE NUMBER AND AVERAGE COST OF WOODEN CROSS TIE RENEWALS PER MILE OF MAINTAINED TRACK AND RATIO OF WOODEN CROSS TIE RENEWALS TO TOTAL WOODEN CROSS TIES IN MAINTAINED TRACK

Class I roads in the United States and Canada, by years, and for the average of the five years 1927 to 1931 inclusive

NOTE: All figures are exclusive of bridge and switch ties

Sheet 5 of 5

Road	Average number of wooden cross tie renewals per mile of maintained track						Average cost of wooden cross tie renewals per mile of maintained track						Average percentage of wooden cross tie renewals					
	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average	1927	1928	1929	1930	1931	5 Year Average
SOUTHWESTERN REGION (CONT'D)																		
St.Louis-San Francisco	184	142	204	168	124	164	$193	$159	$228	$190	$137	$180	5.9	4.6	6.6	5.4	4.0	5.3
St.Louis, San Francisco & Texas	360	234	334	149	133	213	396	293	441	194	170	266	11.4	7.4	10.5	4.7	4.2	6.7
St.Louis Southwestern Lines:																		
St.Louis Southwestern	351	378	332	260	90	278	491	529	455	312	111	373	12.4	11.9	10.5	8.2	2.8	9.0
St.Louis Southwestern of Texas	233	286	348	148	95	221	111	406	498	182	114	305	8.1	9.1	11.1	4.7	3.0	7.1
San Antonio, Uvalde & Gulf	177	210	241	240	225	219	241	281	304	307	288	285	6.3	7.5	8.5	8.3	7.8	7.7
Texas & New Orleans (See note)	226	238	222	173	139	200	339	326	291	223	176	272	8.0	8.6	8.0	6.3	5.1	7.2
Texas & Pacific	393	433	297	170	107	279	495	537	356	194	128	340	12.5	13.7	9.3	5.4	3.6	8.9
Texas Mexican	344	273	302	269	184	274	557	464	474	379	218	416	12.0	9.5	10.5	9.4	6.4	9.5
Wichita Falls & Southern	b	220	215	247	224	227	b	288	273	314	245	281	b	6.7	6.5	7.5	6.8	6.9
Wichita Valley	149	174	200	204	157	177	189	235	244	271	199	228	5.2	5.8	6.7	6.8	5.2	6.0
CANADIAN RAILROADS:																		
Canadian National (See note)		280	260	202	210	249		274	259	210	200	249		9.9	9.2	7.1	7.3	8.8
Canadian Pacific (see note)		250	241	220	210	230		248	263	327	297	285		8.8	8.6	7.9	7.3	8.1
Temiskaming & Northern Ontario		a	a	229	236	243		a	a	174	186	195		a	a	7.8	8.1	8.3

NOTE: Statement applies to Class I roads and includes consolidated data for Class I roads merged during the period 1927 to 1931, as follows:

Grand Trunk Western - includes Chicago,Detroit & Canada Grand Trunk Junction and the Detroit, Grand Haven & Milwaukee.
New York Central - includes Indianapolis & Terre Haute; Cincinnati Northern; Cleveland,Cincinnati, Chicago & St.Louis; and the Michigan Central.
Pennsylvania - includes West Jersey & Seashore.
Reading Company - includes Perkiomen and the Port Reading.
Chesapeake & Ohio - includes Hocking Valley.
Louisville & Nashville - includes Louisville, Henderson & St.Louis.
Duluth, Missabe & Northern - includes Duluth & Iron Range.
Atchison, Topeka & Santa Fe - includes Kansas City, Mexico & Orient.
Panhandle & Santa Fe - includes Kansas City, Mexico & Orient of Texas.
Louisiana & Arkansas - includes Louisiana Railway & Navigation Company.
Texas & New Orleans - includes Galveston, Harrisburg & San Antonio; Houston East & West Texas; Houston & Texas Central; Louisiana Western; and the Morgans Louisiana & Texas Railroad & Steamship Company.
Canadian National - includes Duluth, Winnipeg & Pacific; Atlantic & St.Lawrence and Grand Trunk Western.
Canadian Pacific - includes lines in Maine and Vermont.

a Average number of wooden cross ties not available. b Not a Class I road prior to 1928. c Not a Class I road prior to 1929. d Not a Class I road prior to 1930.

Bureau of Railway Economics
Washington, D.C.
August, 1932.

3. Traffic conditions, such as,
    a. Density
    b. Train speed
4. Climatic conditions
    a. Temperature, and frequency of temperature changes
        (1) Alternate freezing and thawing of the tie
        (2) Heaving of roadbed
    b. Humidity and rainfall
5. Casualties to ties, from extraordinary causes
6. Business conditions
7. Policy of management

B. Average cost of ties used in renewals, which depends upon:
1. Kind of wood
2. Size of ties
3. Source of ties
4. Commercial freight paid
5. Cost of preservation
    a. Kind of treatment
    b. Kind and amount of preservative
    c. Seasoning and storage

Any large system may have most or all of the above variable conditions, and in all degrees. The resulting cost per mile of maintained track is, therefore, a composite figure which may be compared with a similar composite result from a similar railroad, even though some of the variables are different. It would be improper to compare results with a totally dissimilar large road, or with a smaller road not having corresponding diversity of conditions, without making adjustments. Comparisons between small roads, or parts of large systems, should give recognition to the position of each in its tie renewal cycle. Comparisons of five-year averages will be found more accurate and valuable than comparing one-year periods.

The Committee has presented information in its reports on traffic density, number of ties in track, rate of installation of treated ties, etc., which will be found to be of value in making satisfactory comparisons.

The averages reported in Table B of Appendix C are as reliable for the purpose of comparing results on different railroads as most other data commonly used in comparisons of operating efficiency. Such averages as ton-mile cost, train-mile cost, ton-miles per train hour, car miles per car day, fuel consumption per ton mile, and many others, must be used with as much judgment as is required with tie renewal data.

There is no exact formula, and none is possible, for comparing tie renewal costs, but knowledge of conditions will enable proper comparisons to be made, and these can be of very great benefit in determining those tie policies which will be most beneficial in a given case.

Appendix F

(8) METHOD ILLUSTRATING HOW TIE RENEWALS MAY BE PREDICTED UNDER A PROGRAM INVOLVING THE CHANGE FROM THE USE OF UNTREATED TO TREATED TIES

E. L. Crugar, Chairman, Sub-Committee; S. V. Ardagh, M. S. Blaiklock, W. C. Bolin, H. F. Brown, R. E. Butler, John Foley, C. S. Kirkpatrick, A. F. Maischaider, H. C. Munson, L. J. Riegler, J. H. Roach, S. S. Roberts, S. E. Shoup, L. L. Tallyn, K. G. Williams, W. W. Wysor.

Considerable work has been done during the year accumulating data and assembling it in illustrative form but the work is not complete for presentation.

The Committee reports progress with recommendation that subject be continued.

Appendix G

(9) MOST ECONOMICAL METHOD OF DISTRIBUTING TIES FROM TREATING PLANTS TO POINTS WHERE THEY ARE TO BE USED

H. R. Duncan, Chairman, Sub-Committee; R. S. Belcher, Doyle Campbell, H. R. Clarke, R. L. Cook, R. S. Hubley, J. E. King, F. C. Krell, L. O. Lower, C. H. Mitchell, H. C. Munson, S. E. Shoup, K. G. Williams.

It is not possible to recommend any one practice as the most economical method of distributing ties from treating plants to points where they are to be used that will be applicable to all railroads or even to all plants on one railroad.

In the past, it was generally the practice to ship the treated ties from the treating plant at the time the ties were treated. Frequently this resulted in ties being distributed on the railroads many months before they were actually required. Sometimes they were held at the points where they were to be inserted in track and sometimes they were stacked on station grounds or at storage yards. The storage of treated ties at the treating plants was not generally practiced and is a more recent custom where it is now practiced.

The practice of shipping ties as soon as treated grew out of the lack of storage space and the additional cost (at the plant) of stacking and then later loading the ties for shipment. Most commercial plant contracts call for an extra payment for this additional handling.

It is usually necessary or desirable to treat at least some of the ties considerably in advance of the time they are required in the track in order to spread the treating plant schedule over more of the year than the renewal months as well as because ties should be treated as soon as sufficiently seasoned (to prevent over-seasoning and possible decay), and because of yearly variations in weather and other factors, this time when ties will be ready for treatment cannot be forecast with certainty. As the time for use is limited and fairly well fixed, a certain amount of leeway is necessary.

Experience with the older plan of shipping from the plant as soon as ties are treated has been that unavoidably many ties were distributed to the wrong places and reloading and reshipment, or trucking for long distances on the track, were of frequent occurrence. Studies have indicated that considerable economy could be effected by storing the ties after they were treated at the treating plant and then distributing them as they were required.

In some cases where this plan has been adopted the ties have been distributed with tie trains. This practice has developed economies that were not thought possible at the time the plan was inaugurated. By using a special method of stacking and loading the ties, it has been found that they can be very satisfactorily handled on flat cars. This results in much simpler unloading on the right-of-way. It has been found that it is possible to load the ties onto flat cars with locomotive cranes.

The usual practice of distributing ties with tie trains is to have the train accompanied by tie handlers or with section gangs and the train is usually handled under the supervision of the trainmaster and the roadmaster. The roadmaster has shipping notice giving the number of each size of tie on each car and he prepares a memorandum in advance which shows the ties to be unloaded from each car between each pair of telegraph poles, or other fixed locations, the effort being to unload the ties very close to the exact spots where they will be used in track. This results in reducing to a minimum the amount of trucking and rehandling to be done by the section men. Experience results in a rate of

speed which is satisfactory and which permits the ties to be unloaded almost exactly where they are required.

Careful observation of this method of distributing ties indicates that, if properly organized and supervised, it results in economy within that territory adjacent to the treating plant, over which trains may be operated at low rates of speed.

In cases where the territory to be served is a considerable distance from the treating plant, it is doubtful whether ties can be economically transported on flat cars, although, in some cases, they can be distributed from other types of open top cars in a similar manner, and making similar use of special tie trains. Sometimes special cars have been found satisfactory for this method of distribution.

Under other circumstances, it has been found that it is not profitable to use tie trains but it has been found desirable to have the ties distributed, a car at a time, by way freight, the car being accompanied by section men to take care of the unloading. This is a very common and generally satisfactory method and it permits the storage at the plant until just prior to use, as well as the loading of the ties into such types of cars as will minimize hauling empty cars, and other practices which result in transportation and operating economies.

In all cases, all costs incident to the distribution must be considered in arriving at the decision as to method. These costs include the extra handling, if any, at the treating plant, the extra cost, if any, due to unloading from unsuited cars, the additional cost, if any, of back haul of empty cars, the extra cost of rehandling on the receiving division if ties are not unloaded according to "spots", etc.

As the conditions vary so greatly as between different locations, your Committee has found it impossible to recommend any one practice as being superior and, therefore, has endeavored to list some factors that must be given consideration in determining the method to be followed in distributing ties from treating plants to points where they are to be used. It is the conclusion that a careful study should be made by all departments concerned to determine the best method of distributing ties from any individual treating plant.

Appendix I

(11) TIE RENEWAL PRACTICE, INCLUDING METHOD OF INSPECTION AND RENEWAL, CHECK OF SUCH INSPECTION AND ADHERENCE TO SUCH INSPECTION

R. S. Belcher, Chairman, Sub-Committee; M. S. Blaiklock, H. F. Brown, H. R. Clarke, R. I. Cook, E. L. Crugar, H. R. Duncan, C. W. Greene, R. S. Hubley, J. E. King, C. S. Kirkpatrick, F. C. Krell, L. O. Lower, S. E. Shoup, L. L. Tallyn, J. W. Tate, R. C. Young.

As the first step in the development of this subject, your Committee has sent out the following questionnaire. It is recommended that the subject be continued:

COMMITTEE III—TIES—SUB-COMMITTEE (11)

The Tie Committee has been instructed to develop information pertaining to tie renewal practice, including methods of inspection and renewal, check of such inspection and adherence to such inspection.

To secure information on this subject, the following questions have been formulated and it will be greatly appreciated if you will advise the practice of your road. We hope you will not necessarily limit your expressions to your present practice, but in addition, give us the benefit of your judgment in these matters, together with any improvements you feel might be made in present practice:

1. Do you make field inspection to determine renewals necessary?
2. Is field inspection made by
   (a) Section Foreman
   (b) Roadmaster or Supervisor
   (c) Special Inspector
   (d)

3. Are ties to be renewed marked in some manner at the time of inspection? How marked?

4. If not marked, or in addition to marking, is the number needing renewal reported by miles, sections, or districts?

5. Is there a check made of original field inspection? Please describe kind of check made.

6. What has your experience shown to be the tendency in variation, if any, between the original survey and the check?

7. What inconsistencies, if any, do you find in renewal requirements as reported by section foreman, roadmaster, etc., for different territories, under similar condition of tie timber, track and traffic?

8. What plan do you follow for tie allotments in cases where authorized supply is inadequate to cover amounts determined by field inspection?

9. Under the plan covered by question 8, how do you develop data to show the relative importance of renewals where it is necessary to curtail tie renewals and how do you determine where the limited supply of ties is to be used?

10. Do you make inspection of track and old ties taken out of track, after renewals have been completed to determine and avoid extravagant or inadequate renewals?

11. What latitude do you allow section foremen in removing ties at variance with yearly maintenance allotment?

12. What advantage or disadvantage do you find in the practice of spotting ties for renewal?

13. If field inspection is made by special tie inspectors, to whom do they report? Are they accompanied over each Section by the Section Foreman, and if not, by whom?

14. From what line of work are special tie inspectors recruited?

15. How are they trained to secure uniform and satisfactory inspection?

16. What difficulties, if any, do you find in reconciling differences in judgment as to tie renewals between special inspectors and section foremen who are responsible for the safety of track?

17. What advantages and disadvantages has the plan of special tie inspectors for determining the number of tie renewals over other plans?

18. To what extent do you use statistics for the determination of tie renewals?

19. What are the advantages and disadvantages of the use of statistics other other plans?

20. If statistics are used, how do you adjust for abnormal conditions in the previous renewals, especially with reference to newly constructed lines?

21. Do you consider that the plan of using statistics gives more economical results in the use of ties?

Appendix E

(7) ECONOMICS OF THE USE OF 8-FOOT 6-INCH AND 9-FOOT TIES AS COMPARED WITH 8-FOOT TIES

J. E. King, Chairman, Sub-Committee; M. S. Blaiklock, W. C. Bolin, E. E. Chapman, S. B. Clement, R. L. Cook, C. W. Greene, L. J. Riegler.

As indicated by previous report, the Committee is of the opinion that further data can be secured which will permit establishing reasonably correct limitations within which the different lengths and sizes of ties may be economically used.

It is the plan of the Committee to establish one or more test sections of one mile each where new track is being constructed, installing 8-foot ties in one-third mile, 8½-foot ties in one-third mile, and 9-foot ties in one-third mile, comparing and studying maintenance costs.

Business conditions, however, have prevented the establishment of such test sections, and it is recommended that the subject be continued, with the view of establishing test sections as early as practicable.

Appendix H

(10) ECONOMICAL USES FOR OLD TIES WHICH MUST BE REMOVED FROM TRACK AND BRIDGES—A, TREATED; B, UNTREATED

H. R. Clarke, Chairman, Sub-Committee; R. S. Belcher, H. F. Brown, Doyle Campbell, E. E. Chapman, S. B. Clement, R. L. Cook, C. W. Greene, R. S. Hubley, J. E. King, C. S. Kirkpatrick, F. C. Krell, L. O. Lower, A. F. Maischaider, J. H. Reeder, J. W. Tate, K. G. Williams, R. C. Young.

The Committee understands this assignment to refer to ties which for various reasons must be removed before they are unfit for continued economical use in their original locations.

It is the opinion of the Committee that the greatest economy can be realized by leaving a tie in its original location if possible until it is so decayed or mechanically worn that no further service can be had from it.

The two most common causes for release of ties while still serviceable are: first, abandonment and taking up of track or filling of bridges; second, mechanical wear which has progressed to a point where a tie no longer gives satisfactory service and support in heavy-duty track. Under these conditions ties are released which may again be used with economy.

When tracks are abandoned and taken up or bridges are filled, ties in all stages of service and consequent condition may be released. It is recommended that such ties be carefully inspected and sorted and those estimated fit for at least five years' service be again installed where similar ties are located. Generally, second-hand ties have had their original quality lowered and should be used in the less important tracks where ties of such character are suitable.

Because of the cost of installing them, it is not considered economical to reuse ties unless they will have an estimated life of five years in their new location.

The removal of ties from high-speed, heavy-traffic lines is at times necessary on account of mechanical wear, even though little or no decay has developed, and in locations such as through tunnels, station platforms and on ballast deck bridges, where renewal of all ties periodically is economically justified, some ties suitable for further use are released. Such ties may be reinstalled to advantage in yard and side tracks and on light traffic branches, after the inspection and under the service stipulation recommended above in the case of ties released by taking up track or filling bridges.

When ties are reused, they should be put in track with the same surface up as in the original location, and all spike holes completely filled with treated tie plugs. When satisfactory new bearing cannot be provided by carefully adzing the original top of the tie, it may be turned over. Creosote (preferably hot) should be applied to all newly-exposed surfaces.

In the case of track ties which cannot be reinserted under the above specifications, the following possible uses are suggested:

1. Fence Posts. A tie removed on account of mechanical wear or because badly split may contain sufficient sound wood to make a satisfactory fence post. A large tie should be split so as not to require excessive digging in order to set it. Splintered or decayed wood should be trimmed off to retard further decay and reduce fire danger.

Short posts for intermediate use in woven-wire, hog-tight fence can frequently be made by sawing off the decayed or shattered ends of ties.

The cost of preparing, handling and setting old ties as posts may compare favorably with such expense for posts of other types only when old ties can be used near where released, and so result in minimum expenditures for handling and shipping.

2. Narrow-gage Ties. Cross-ties removed from standard-gage tracks may be shortened and used to advantage in narrow-gage tracks of repair, material, or seasoning yards.

Switch ties may often be cut to a shorter length or to cross-tie length with decided economy.

3. Retards or Deflection Dams to Prevent Erosion. Old ties set on end, either solid or spaced as the result desired requires, will last for a number of years in controlling erosion and in diverting water.

4. Cribbing of Crib Walls. (Bridge-ties are more suitable than cross-ties).

5. Runways or Paving on Motor-car Setoffs.

6. Paving Stock Yards, where more permanent paving is not justified.

7. Scrap Bins at section tool houses.

8. Kindling for starting fires in locomotives. A careful record and check on the cost of piling, picking up, hauling and preparing is necessary for comparison with other material for this purpose.

9. Mud Sills under stacks of ties or other material along the right-of-way.

10. Exchange with adjoining landowners for such work as grading, plowing fire lines, mowing weeds, etc.

11. Sale to adjoining landowners for fuel or other use.

Bridge-ties removed on account of mechanical wear may be used in all of the above ways. On account of their large dimensions, they are particularly suited for use as stock-yard posts, gate posts, etc.

The above recommendations apply particularly to treated ties. In general, the same uses may be made of untreated ties under the same restrictions. As the further service that may be expected from an untreated tie is reduced to a greater extent by moving it than in the case of a treated tie, more careful calculation is necessary when consideration is given to their reuse. Consequently there is less opportunity for economical use of second-hand untreated ties.

The Committee wishes to suggest that the use of second-hand material can be, and frequently is, overdone, for the tendency seems to be to use it where it is false economy to do so. Therefore all cost factors must be carefully considered.

REPORT OF COMMITTEE XXVII—MAINTENANCE OF WAY WORK EQUIPMENT

C. R. KNOWLES, *Chairman;*
G. A. W. BELL, JR.,
W. A. BATEY,
M. D. BOWEN,
WALTER CONSTANCE,
W. O. CUDWORTH,
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J. G. SHELDRICK,
HARRY SLABOTSKY,
H. W. STETSON,
F. M. THOMSON,
N. M. TRAPNELL,
J. B. TRENHOLM,
FRED ZAVATKAY,

Committee.

To the American Railway Engineering Association:

Your Committee presents herewith report on the following subjects:

(2) Standardization of parts and accessories for railway maintenance motor cars (Appendix A). It is recommended that this report be adopted for publication in the Manual as recommended practice.

(4) Types of snow-melting devices as an aid in facilitating train operation and reducing maintenance cost (Appendix B). This report is submitted as information.

(5) Use and adaptability of track type tractors in maintenance of way work (Appendix C). This report is submitted as information.

(9) Organization for the use of tie-tamping machines, air and electric (Appendix D). This report is submitted as information.

(12) Tie adzing, scoring and boring machines (Appendix E). This report is submitted as information.

(13) Use of ditching-spreaders (Appendix F). Submitted as information.

Progress is reported on the following subjects:

(1) Revision of Manual.

(3) Adaptability of air and electric driven tools in railway maintenance of way work (track grinders).

(6) Methods of keeping data on work equipment and labor-saving devices.

(7) The selection and training of maintainers and operators of work equipment.

(8) Use of ballast discers.

(10) Rail laying machines and auxiliary equipment.

(11) Use of weed destroying equipment, including horse-drawn and power mowers operating both on and off the track.

(14) Manual of instructions for care and operation of maintenance of way work equipment.

(15) The use and maintenance of paint spraying equipment with outline of typical organizations for various classes of work.

(16) Organization for the use and maintenance of ballast cleaning machines and conditions under which each particular type may be used.

(17) The use of oil spraying machines for oiling rails and fastenings, steel structures and roadbed.

Respectfully submitted,

THE COMMITTEE ON MAINTENANCE OF WAY WORK EQUIPMENT,

C. R. KNOWLES, *Chairman.*

Bulletin 351, November, 1932.

Appendix A

(2) STANDARDIZATION OF SECTION DUTY MOTOR CAR PARTS AND ACCESSORIES

G. R. Westcott, Chairman, Sub-Committee; Walter Constance, Paul Hamilton, T. H. Harris, Jack Largent, E. H. Mills, E. H. Ness, C. H. Ordas, J. G. Sheldrick, F. M. Thomson, N. M. Trapnell.

As a continuation of the studies that have been made in the last several years, resulting in recommendations that have been accepted by the Association covering designs for wheels, axles, couplers, safety rails, tool trays, frame bolts, gasoline lines, windshields, rail skids and extension lifting handles, for use on motor cars, your Committee has this year given further study to the subject of fuel line connections and has also considered sizes of cord belts, gas tanks, brake shoes and ignition systems.

In making this study, information on the practice of different manufacturers, as well as the views of a number of railway representatives having experience in the maintenance of motor cars, has been considered.

Progress is also reported on certain details of fuel systems, lubrication of chassis, and ignition systems, not heretofore considered.

The following is offered as recommended practice:

1. Gasoline lines shall be annealed copper tubing of not less than No. 19 B.W. gage in thickness, having ¼ in. outside diameter. Gasoline line connections shall be of packing type (see Fig. 1) with ⅛ in. pipe thread (⅛ in. diameter, 27 threads per inch, National taper pipe thread) on one end and ½ in. SAE standard free fit thread (½ in. diameter, 20 threads per inch, National Fine Series, Class 2 fit) on the other end.

2. On belt driven cars, belts of the endless cord type are desirable, and where practicable lengths of 97 inches or 103½ inches should be used. While an endless cord belt 3½ inches wide is adequate in strength for section motor car service and is stronger than a 4-inch laced belt, the fact that the latter has 14 per cent greater friction surface on the pulley must be considered in choosing the proper width.

3. Gasoline tanks should be made of not less than 22 B.W. gage terne plate, be cylindrical or oval in shape with concave or convex ends, and seams locked and soldered. Filler openings should be 1⅝ in. inside diameter equipped with bayonet type cap having gasket and inner splash cone, $\frac{1}{16}$ in. vents being provided in cap and splash cone.

4. Where brake blocks of wood are used, they shall have facings of cast or malleable iron not less than ¼ inch thick, bolted to the blocks with ¼ inch bolts. These facings shall be properly insulated where necessary.

5. Spark plugs shall have ½ in. tapered pipe threads (½ in. diameter, 14 threads per inch, National taper pipe thread) with tolerance such that plug will screw into a Pratt and Whitney or Briggs gage, by hand, so that the bottom of the threaded portion lacks from ½ turn to 1½ turns of being flush with the face of the gage.

Action Recommended

1. That the above specifications 1 to 5 inclusive, together with Fig. 1, be adopted as recommended practice for inclusion in the Manual.

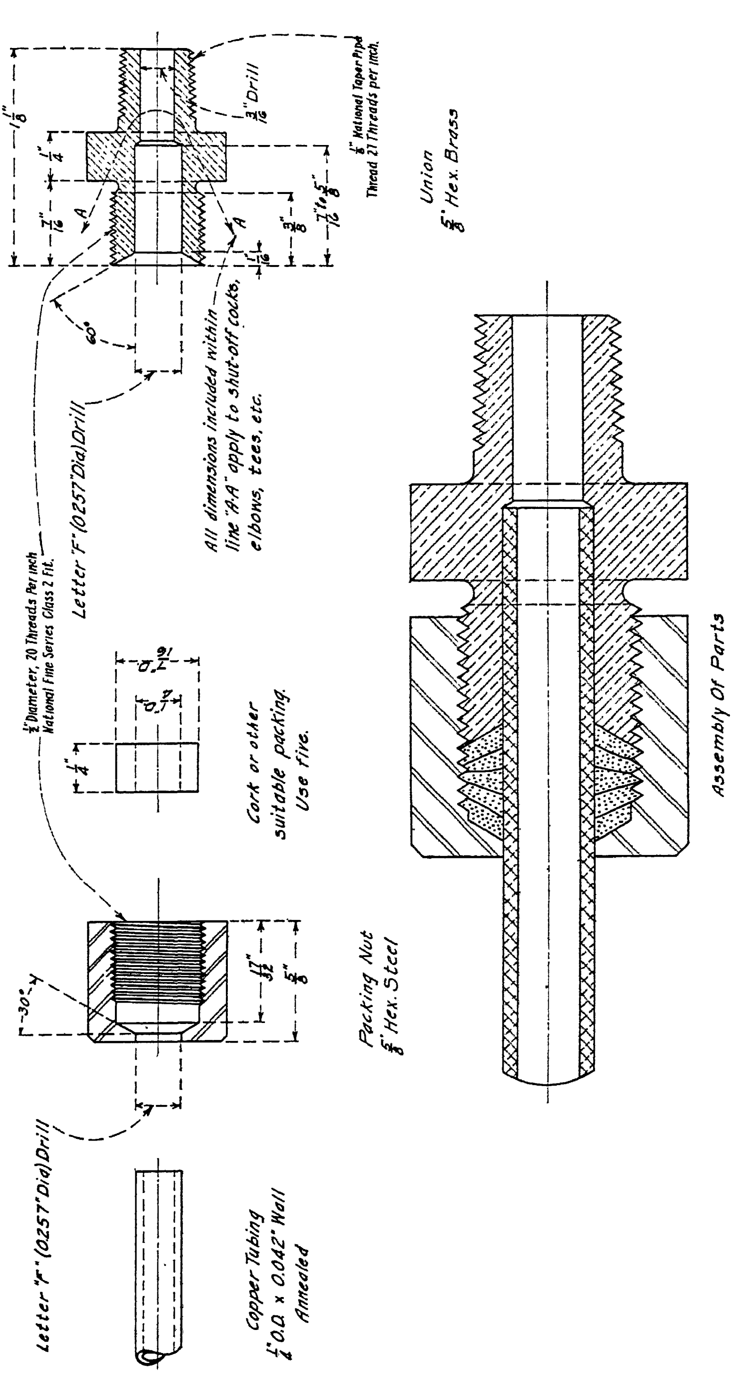

Fig. 1.—Gasoline Line Connections.

Appendix B

(4) TYPES OF SNOW-MELTING DEVICES AS AN AID IN FACILITATING TRAIN OPERATION AND REDUCING MAINTENANCE COST

F. S. Hewes, Chairman, Sub-Committee; J. F. Donovan, C. L. Fero, A. I. Gauthier, W. R. Gillam, R. C. Haynes, L. B. Holt, A. J. Neafie, E. Pharand.

Introduction

Snow-melting devices aid in facilitating train operation and in reducing maintenance cost. There are various types to meet the requirements of different localities. Information is presented in this report on these three features; preceded by a general discussion and followed by a list of manufacturers and of railroads using the various devices, bibliography, and by the conclusions.

It is the purpose of this report to consolidate information secured from publications, railroad users and manufacturers. No doubt, additional data will be available as these melters come into more general use, and it is thought that such should be incorporated in supplementary report or reports.

General Discussion

It is considered that the assigned subject of this report relates principally to the protection of tracks from snow. This includes, generally, ordinary and spring switch points, slip switches, split point derails, movable point crossings, car retarders, etc.; all of which have moving parts that are interfered with by snow. For ordinary trackage necessary to be freed from snow, other methods outside of this study, are used.

Another side to the subject is the protection of station and other platforms, runways, driveways, and movable parts of bridges. Here the problem is different and the same methods cannot be followed as for the track.

For track layouts, snow-melting devices that use steam, oil, gas or electricity for the heat agency, are placed at or applied to the movable parts to remove the snow as it falls or drifts. For platforms, etc., the chief means other than shoveling, plows, etc., is to use chemicals. These are not so effective for track.

Until about fifteen years ago, few snow-melting devices were in use; consisting principally of steam jets on locomotives, steam coils, salt, and the burning of either hydrocarbon oil or kerosene. As labor became scarcer and traffic heavier, a demand was created for further developments to replace manual methods. This was in common with the growing trend to use all other kinds of successful maintenance of way work equipment. Until five years ago, the development of snow-melting devices was slow, but since then it has been comparatively rapid.

The increased importance of train speed, dependability of operation, and lessening of expenses during recent years, have tended to enhance the value of snow melters at strategic points of important terminals subjected to delays due to snow. All such delays cost money and are not a good advertisement, nor do they gain any good-will from the public. Accumulations of snow and ice at terminals may delay traffic over adjacent portions of the line.

So far, the Chicago area seems to have used more melters than colder sections of the United States and Canada. This is likely due in part to it being the largest railroad center, but the geographical location seems to have its effect. Most of its snowstorms occur at a temperature from 10 degrees below freezing to about freezing, and seldom last over two days. There is a sufficient interval to clear up one storm before another comes.

Farther north, or in higher altitudes, where the snow accumulates all winter and the temperatures are low, the melters have been less successful. They produce water from the melted snow and unless the drainage is good, there is a large accumulation of ice just outside of the effective limits of the melters.

In determining whether or not snow-melting devices of other than the simplest kinds should be used, and the best type and capacity for the location, study may well be made of the following:

Experience of other railroads
Cost of melters plus installation and maintenance of same as compared with cost of manual methods
Delays and injuries under manual methods
Track layout
Clearances
Space available for underground pipes or conduits or overhead wires
Importance and volume of traffic
Speed of trains
Dependability of train operation
Rapidity and amount of snowfall
Wind velocity during snowstorms
Temperatures during snowstorms
Cycles of thawing and freezing
Drainage of piping systems and melted snow
Sufficient, reliable and economical supply of steam, oil, gas or electricity

The Weather Bureau records nearest the location considered may profitably be consulted for ten years back. It will generally be found that the storms were not as severe or as frequent as one's memory would indicate.

Other features to be considered:

For open flames of all kinds:
- Possible damage to rolling stock or contents, insulation, rail
- Fire hazard
- Hazard of injury to employees
- Smoke may obscure signals

If steam is used:
- Feasibility of installing underground pipes
- Condensation to be provided for
- Escaping steam may obscure signals
- Full head of steam not always available

If oil is used:
- Fire hazard and wastage in storage of winter supply
- Feasibility of installing underground pipes

If gas is used:
- Feasibility of installing underground pipes
- Large pipes to guarantee sufficient gas at times of storms, due to increased use elsewhere and contraction in cold weather
- Moisture in gas

If electricity is used:
- Cost
- Feasibility of installing overhead wires or underground conduits

Facilitates Train Operation

Dependence on manual labor to keep tracks and track structures open to traffic at time of severe snowstorms results in a large expenditure for extra laborers and usually delays to train movements are general, rather than the exception.

The savings in train operation due to use of snow-melting devices is difficult to express in money, but comparison of delays between terminals in the same locality, with and without such devices, may be had; also, comparison of operating conditions in the same terminal, before and after installation.

For instance, installations of snow-melting devices at a certain Chicago terminal proved their value on two recent occasions, December, 1929, and March, 1930. This terminal was quite fully protected with modern devices and was practically the only layout in the same locality that provided for all train movements without interruption and with practically no delay. Such delays as did occur were the result of conditions outside of the terminal area. Other transportation agencies were either completely paralyzed or so seriously handicapped that they just escaped complete interruption to their service. Some trains were up to seven hours late, and some roads had to discharge their passengers six or seven miles from their downtown terminals.

The March, 1930, storm had a record-breaking snowfall of 19 in. in 48 hours, with a 35 mile wind, and temperature of 23 to 32 degrees Fahr. In March, 1931, the Chicago area had a fall of 16 in. in 39 hours, accompanied by a 43-mile gale, thus drifting the snow badly. The temperature was from 26 to 33 degrees. During the first mentioned storm, the railroads, in most cases, had to abandon their passenger train schedules, as indicated above. During the latter storm, passenger trains of most railroads arrived and departed with practically no delay. The reason for this difference in operation was due, principally, to the abandonment of hand methods of clearing switches and the installation of snow-melting apparatus at key positions.

Under manual methods, it had been customary during severe storms to abandon the use of freight tracks leading to a Chicago terminal and concentrate all efforts on keeping the passenger tracks open, yet delays to passenger trains were numerous and derailments common. After installation of snow melters, no difficulty was experienced in keeping all tracks open during the period of the March, 1931, storm; there were no train delays chargeable to the operation of the interlockers and no derailments.

A Chicago freight terminal, during recent severe snowstorms, has kept its hump yard operation uninterrupted by using weed burners to clear the car retarders; while the operation of similar installations in other yards, not protected by melting apparatus, had to be suspended.

Reduces Maintenance Cost

Before the general use of snow melters, it was the universal practice to hire a large force of extra laborers to keep the tracks open at strategic points, by use of shovels and brooms. Such labor is usually unsatisfactory, requires an unusual amount of supervision and risk of accidents is greatly increased due to the many men on the track, poor visibility, and the necessity for the men to be bundled up—particularly having their ears covered. Also, it frequently is the practice to pay off such labor at the end of each day's work, which increases the work of timekeepers and clerical forces.

In January, 1918, some of the worst snowstorms in Chicago occurred, 42.5 in. falling during the month. During the first 17 days, 31 in. fell, the temperature was from 14 degrees below zero to 31 above and the maximum wind was 44 miles. One railroad with a large terminal (about 2200 switches and 85 double slips) found it necessary to hire the following extra men in addition to its regular force:

Jan. 1	193	Jan. 7	615	Jan. 13	1575
2	170	8	1056	14	1575
3	192	9	1340	15	1015
4	96	10	1155	16	1015
5	96	11	1130	17	780
6	704	12	575		
				Total men-days	13282

It is not thought that snow melters could have eliminated all of this labor, but it surely would have reduced it greatly.

During the March, 1926, snow, several Chicago railroads each hired about 500 outside men, augmented by a larger number from their mechanical and freight house forces, but with all this, train service was paralyzed.

In March, 1931, when Chicago had a snowstorm of 16 in. in 39 hours, one railroad used 4000 oil-burning pots to protect 237 main track switches, 4 single slips and 41 double slips. It required only 80 men to tend and refill these, as compared with 736 men without this equipment. Maintenance saving is estimated at approximately $7000, including labor and all supplies, such as oil, brooms and shovels. This represents for this one storm a saving of over 40 per cent on the investment.

During this same storm, the same road used its regular section force of 35 men and 3 weed burners to clear 514 switches and 200 retarder units. One weed burner broke down and it was necessary to rush 80 extra men to take its place in keeping the switches clear.

At the same time, a Chicago passenger terminal had 31 double slips and 19 switches equipped with 3318 gas burners. The previous year, only 4 double slips were protected by gas melters, but 2 single slips and one switch had steam coils protection. The 1931 expense of clearing the terminal of snow was $2000 less than for 1930, and no extra labor was required.

At an important interlocking layout in Chicago, where one railroad's four main tracks cross a like number of another's important main tracks, there were no melters used in 1929 or 1930, but during 1931, 2000 gas burners were in service to protect 25 switches, 9 double slips and 14 movable point crossings. Comparing the March, 1931, storm with that of March, 1930, a saving of approximately $2800 was realized on maintenance for one storm, representing approximately 17 per cent on the original installed cost. This saving considers all labor and supplies for each storm, including brooms and shovels or cost of gas consumed. After installation of these melters, the regular force of 8 to 20 men were used instead of 150 to 500 formerly required.

Snow melters were not used elsewhere in the Chicago area of the above road and during the March, 1931, storm, the regular force of 100 men was increased by 1800 outside laborers. This was to take care of approximately 2000 switches.

A neighboring railroad is now able to cope with the snow with a maintenance force of 29 men during severe storms where formerly 850 were needed, due to protecting 49 turnouts, 31 double slips and 3 single slips with 4882 melters. This same road estimates they save $55 per switch each year, representing 30 per cent of the installed cost, where these turnouts are protected by gas melters.

The experience of a Chicago electric road during a snowstorm in March, 1932, when 9 in. of snow fell, is another endorsement for snow melters. The saving by using gas at one of their yards during this storm resulted in a saving which amounted to 20 per cent of the investment when compared to the cost of combatting the 19 in. snow of March, 1930. Man-hours were reduced from 5964 to 1123.

A New England railroad has equipped 100 of its switches in a terminal with fixed oil-burning melters using snow-melting oil. During a recent eight-hour snowstorm, a saving of approximately $280 was realized. This represents about 4 per cent on the installed cost for this one storm. Nine men were used where formerly 100 to 150 were required.

This same road, at another terminal, with the same kind of devices on 50 switches, used only 3 men, where 75 to 80 were necessary at previous severe snowstorms.

Another road has 15 switches at the throat of a tunnel protected by melters of the same kind, and uses only one man and one gallon of oil per hour per switch, during storms.

One railroad with 397 pot type oil burners reduced its maintenance cost $1240 during the first winter, representing about 50 per cent on the installed cost.

Using one of the smallest model weed burners, a northern road made a decided saving over manual methods in removing a 4 to 5 in. snow, which in places had drifted up to 18 in. Sixty-seven switches, 3 double slips, 2 railroad crossings, 1 highway crossing, and 3 miles of track were flanged in 4 hours including delays due to train movements which amounted to an hour and fifteen minutes. There was a total of 12 man-hours as compared to 176 which, based on previous experience, would have been required by manual methods. Two hundred and fifty gallons of fuel oil were used by the weed burner.

A Chicago passenger terminal equipped with gas snow melters, has just about paid for this apparatus, during the three severe snowstorms, since installation.

Types

Snow-melting devices may be grouped as follows:

Chemicals:

1. Salt
2. Calcium chloride
3. Patented powders

Heaters:

Portable:

4. Snow-melting cans
5. Torches: self-generating
6. Torches: vacuum
7. Weed burners
8. Steam jets on locomotives

Semi-portable:

9. Oil burning pots or boxes

Fixed:

10. Steam coils under switches, etc.
11. Steam pipes in pits
12. Oil melters: intermittent spraying
13. Oil melters: constant burning
14. Gas melters: hand lighted
15. Gas melters: electrically ignited
16. Electric melters: radiation
17. Electric melters: contact
18. Electric melters: combination radiation and contact

Following is a brief description of each group and device in the order listed:

Chemicals: Chemicals have a pronounced effect on the lowering of the freezing point of the resulting solution and are one of the most widely used agents in the removal of ice. Their special field is the removal of ice from platforms, runways, etc., but they have also been used around switches, etc. In warmer regions where formation of ice is rare, they are probably the only economical melting agent. They are generally effective in sleet storms, but are not of much force for snows. The ordinary chemical melters are low in cost and are readily procured. They are all easily applied. Corrosion is accelerated when the commonly used chemicals come in contact with metals, they have a deteriorating effect on electrical insulations and are liable to short circuit electrical circuits.

1. Common salt is the most commonly used chemical and is cheap. It is not effective where the temperature falls much below the freezing point of water.

2. Calcium chloride costs about two-thirds more than salt, but is effective to lower temperatures and is not so corrosive.

3. Nivosal is a patented snow-melting powder which is effective to much lower temperatures than either of the above. It not only lowers the freezing point of the resulting solution to twenty degrees Fahr. below zero, but generates considerable heat in going into solution. As it has no corrosive action on metal, it can be used where other chemicals cannot. Because of its higher cost, greater care must be exercised in its use to secure the most economical results. Skin burns and damage to clothing are liable to result from careless handling. It is imperative to keep the powder sealed from exposure to moisture when kept in storage.

Heaters: Heaters include all snow melters other than chemicals. The heat agencies used are steam, oil, gas, and electricity. The characteristics of the various types vary so widely that no general remarks are applicable to the class as a whole. Sketches of most of the different types are included in this report. Where a track layout is shown, it is that of a typical interlocked turnout switch, 16.5-ft. long. The number and location of these melters may be altered due to climatic or other local conditions. For switches of other lengths or for more complicated track structures, such as slip switches and car retarders, modifications of the installation would, of course, be necessary.

4. Snow-melting cans are used to pour a flaming fluid onto the snow or ice to be removed. The unit usually consists of a three-gallon can having a pouring tube about 3 ft. long equipped with a pilot wick on the discharge nozzle, which ignites the fuel immediately upon it leaving the nozzle. The pilot wick continues to burn for some time after the flow of oil is shut off, avoiding the necessity of relighting in moving from place to place. A valve with a handle extending to the top of the can is used to regulate the flow of fuel. The fuel used is a highly inflammable low-flash oil, such as casing-head gasoline, low pressure hydro-carbon or special snow-melting oil. Snow-melting cans are particularly adapted for light snows or ice formation, especially around interlockings and outlying switches. They are not an efficient method of removing heavy snows and their efficiency is further impaired by strong winds. Care must be exercised to prevent burning of timbers, trunking and insulations.

The two types most commonly used are the Greer and the Protectoseal, which are briefly described as follows, in addition to the above general description:

The Greer Safety Can has baffle plates in the nozzle to prevent explosions and backing up of the flame. In addition, it has an automatic check valve, which prevents the flow of fuel until the pouring tube has been tipped to an angle of 45 degrees. A vent in the filling cap serves as a vacuum breaker and a pressure relief. This vent is also protected with a baffle plate. A double cylindrical brass strainer 6 in. long is inserted in the filling cap. This strainer serves to minimize the danger from explosions. The nozzle is asbestos wrapped (Fig. 1).

The Protectoseal Can is similar to the Greer except it has a combination brass torch and nozzle, and does not have either the baffle plates or the automatic check valve. However, safety is assured by the insertion of a fire screen at the nozzle and a double cylindrical strainer at the filling cap.

5. Self-generating torches differ in principle from snow-melting cans in that the liquid is forced by pressure developed by a hand air-pump into a preheated burner where it is burned. In this type of torch the liquid does not burn on the snow;

melting is accomplished by contact with heat from the flame. The fuel used is generally kerosene. The flame usually has a temperature of from 1600 degrees to 1800 degrees Fahr., and varies in size from 2.5 in. by 25 in. for the smaller burners to 4 in. by 35 in. for the larger ones. Fuel consumption ranges from one-half to three gallons per hour per burner. The average life of the unit as a whole runs from 5 to 10 years with a much shorter life for the burner, probably 1 to 3 years. Maintenance charges will run about

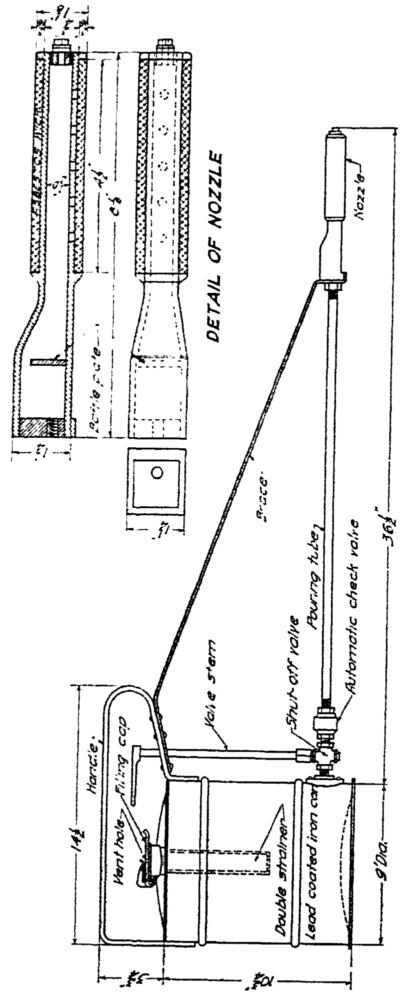

FIG. 1.—GREER SAFETY SNOW-MELTING CAN.

10 per cent of the cost of the unit per year. This type of torch is especially adapted for use in cleaning up after the bulk of the snow has been removed by manual methods. There usually remains, after a general clean up, small accumulations of packed snow or ice which interfere with the operation of various switch and interlocking mechanisms, which cannot be readily reached by brooms or shovels. In such cases the torch comes in very handy. They are not efficient in the removal of large quantities of snow and

strong winds impair their efficiency. These torches develop a higher temperature, are under better control, the fuel (kerosene) is more readily procured, and they are safer to handle than snow-melting cans, and being self-contained are more flexible than the vacuum torches. Incidentally these torches are in general use for other purposes, especially at car repair shops, and are readily available. Their disadvantages are the large number required with the consequent increase in labor to handle, and the fact that as they are of the self-generating type, they are subject to carbonization.

There are three types of these torches as follows (Fig. 2):

(a) Burner fastened directly to a 1.5 to 3 gallon tank.
(b) Burner connected to the tank by a flexible hose, the tank, 3 to 5 gallon capacity being small enough to be conveniently carried in one hand while using the other to manipulate the burner.
(c) One or more burners connected to a comparatively large tank (10 to 20 gallons) by means of flexible hose.

There are a number of different makes of this type of torch; namely, Buckeye, Chausse, Hauck, Littleford, Mahr and Unique.

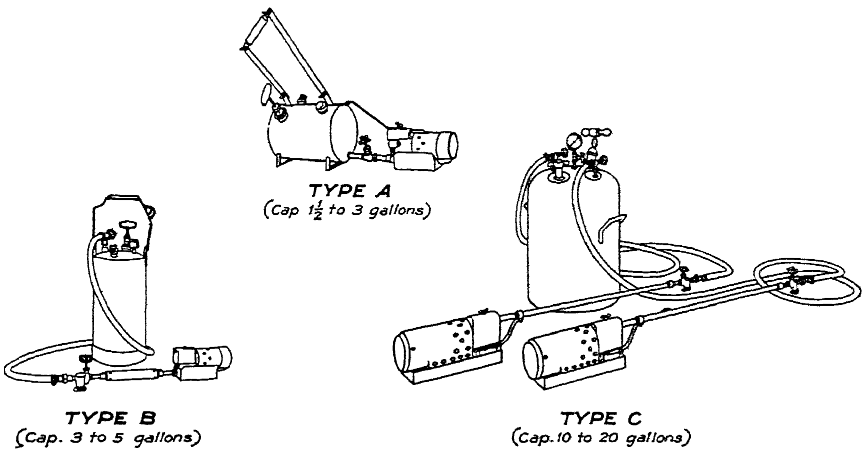

FIG. 2.—SELF-GENERATING TORCHES.

6. In the vacuum type torches, there is no pressure on the oil in the tank. Air pressure supplied to the burner creates a partial vacuum in an independent fuel line, which draws the oil to the burner. Should either the air or fuel line be cut, the oil flow stops instantly as the suction ceases. Each burner is attached to the tank (which may be any convenient oil barrel or tank) and to the source of compressed air by independent flexible hose lines. The torch operates on fuel oils, distillates and all lighter oils, burning from 1.5 to 14 gallons of fuel per hour and requiring from 5 to 40 cu. ft. of air per minute at a pressure of from 50 to 100 lb. The advantages of the vacuum torch over the self-generating types are a greater degree of safety, a larger and hotter flame (flame runs up to 60 in. in length), they are more substantial, do not carbonize, are more easily ignited, and do not require a specially constructed fuel container. Like the self-generating types, they are in somewhat general use for other purposes. Their chief disadvantage is the fact that they can be used only where a source of compressed air is available. Generally, manufacturers of the self-generating torches also make the vacuum type (Fig. 3).

7. Oil-burning weed burners have been used to clear switches, etc., of snow and ice and have proven especially effective in keeping car retarders clear. While the regular weed burner nozzles have been used in the past, special nozzles for snow melting have recently been developed. The new nozzles are capable of burning twice the amount of oil usually used in weed burning and are so constructed that the air for combustion is preheated to a temperature of from 250 to 300 degrees. These nozzles may be set to throw the flame parallel to or at right angles to the track as conditions may dictate. It is possible to manipulate the burners to reach any point within a distance of 25 ft. from the center of the track occupied, thus permitting 3 tracks to be cleared while occupying only one. The advantages of using this type of melter is its flexibility in operation and the fact that it extends the working period of the weed burning equipment. The disadvantages are the liability of interference to train movements and the fact that the roar of the flame may prevent the operator hearing signals. The principal makes used for snow-melting are the Fairmont and the Woolery.

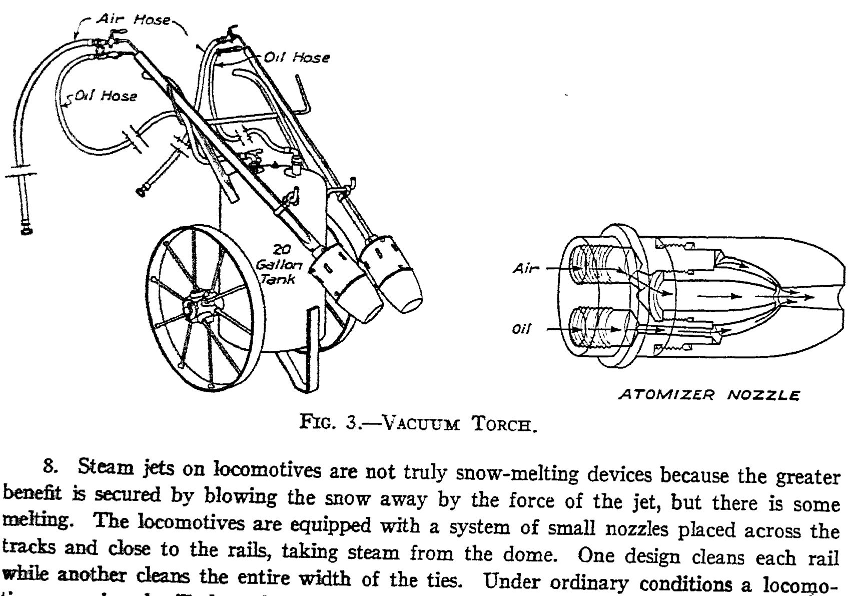

FIG. 3.—VACUUM TORCH.

8. Steam jets on locomotives are not truly snow-melting devices because the greater benefit is secured by blowing the snow away by the force of the jet, but there is some melting. The locomotives are equipped with a system of small nozzles placed across the tracks and close to the rails, taking steam from the dome. One design cleans each rail while another cleans the entire width of the ties. Under ordinary conditions a locomotive so equipped will clear about 20 switches per hour. Traveling 3 to 5 miles per hour, they are effective in clearing snow 12 to 14 in. deep. The cost of equipping a locomotive will run from $30 to $100. The advantages of this method are its flexibility, the ease of equipping the locomotive and the fact that a locomotive would generally always be available at terminals where there would be a large number of switches to be cleared. The disadvantages are that the flying snow and dirt are a hindrance to vision besides covering everything in its range, the slush formed may later freeze, the noise from the escaping steam is an interference to audible signals, and at heavy traffic points, this method complicates the movements of trains in their occupancy of tracks. Cinders and ballast must sometimes be swept off slide plates before switches can be thrown (Fig. 4).

9. Oil burning pots or boxes are designated as semi-portable and are normally set in position when the storm approaches and removed at its subsidence. When left in place they are liable to become clogged with dirt and cinders. However, the newer types have been designed to permit remaining in place the entire winter and some roads are

now following this practice. They burn kerosene or similar oils, and are placed under the rail between the ties. The proper fuel is a matter of great importance to their successful use. Some oils result in so much heat that the oil boils over, while others are difficult to ignite. They have come into quite general use due to their low cost, their effectiveness, and the fact that they can be handled by ordinary labor. The disadvantages are the expense of refilling, the possibility of the flame and smoke obscuring signals and the fact that they are very dirty. In addition, the flames may be injurious to rolling stock and unless special protection is provided, they may burn the ties. In high winds they are liable to be blown out.

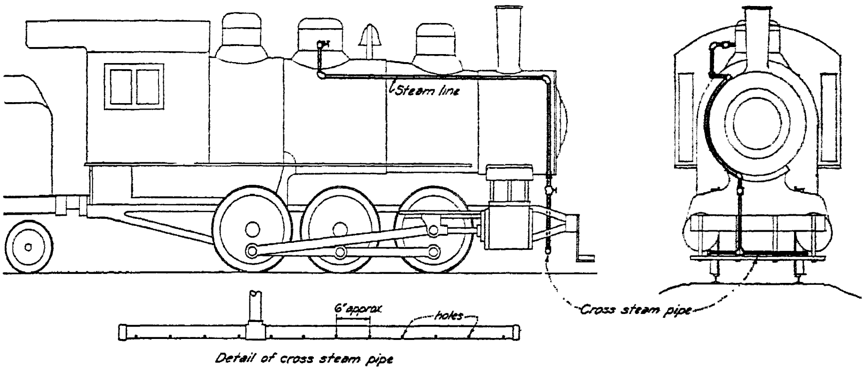

FIG. 4.—LOCOMOTIVE EQUIPPED WITH STEAM JETS FOR SNOW MELTING.

There are several types of these pots as follows:

(a) Open wickless pots are either cast iron pots or 4 or 5 in. sections of 4 in. pipe having a plate welded to the bottom. One filling will last about 2.5 hours and it is necessary to use a special can to fill them if they are to be filled while burning. Very few of these are now being used.

(b) Servrite: This is a special cast iron pot with a system of flues cast along the circumference. These flues are open to the atmosphere near the base of the pipe and open into the pot near the top. It is claimed that this construction reduces the liability of the flame to be extinguished and as a consequence less labor is required to attend them. Very few of these are now being used.

(c) Winter King: Consists of a steel box 18 in. by 4.5 in. by 5.5 in. high (plus additional 2 in. for flanges). This box has a capacity of about 1.5 gallons, sufficient for about 9 hours of ordinary operation. A combustion or wick chamber about 3 in. by 4 in. by 5.75 in. high is inserted at the flanged end of the box and as it extends about a quarter of an inch above the top of the box, water does not drain into it. The wick chamber is packed with either asbestos or mineral wool, and has a series of vertical slots extending upwards from the base for the admission of the fuel. A sliding cover with thumb screw attachment permits regulation of the heat and in addition may be used to seal the wick chamber against accumulations of dirt when not in use. A flange on each side of the opening maintains the proper distance between the heater and the bottom of the switch point and is intended to protect the ties. In the top of the fuel chamber, there is a small opening with a self-closing cap for filling. Since this opening is removed from the flame, there is no necessity for using a special filling can even when the melter is burning. Experience has shown that it is better to place the combustion chamber directly underneath the running rail, rather than under the space between the running rail and the switch point (Fig. 5).

(d) Protectoseal: Somewhat similar to the Winter King. While the dimensions of the box vary somewhat, the capacity remains the same. A round wick is enclosed in special housing which extends above the top of the box and is provided with vent holes at the side and a sliding cover over the top (Fig. 6).

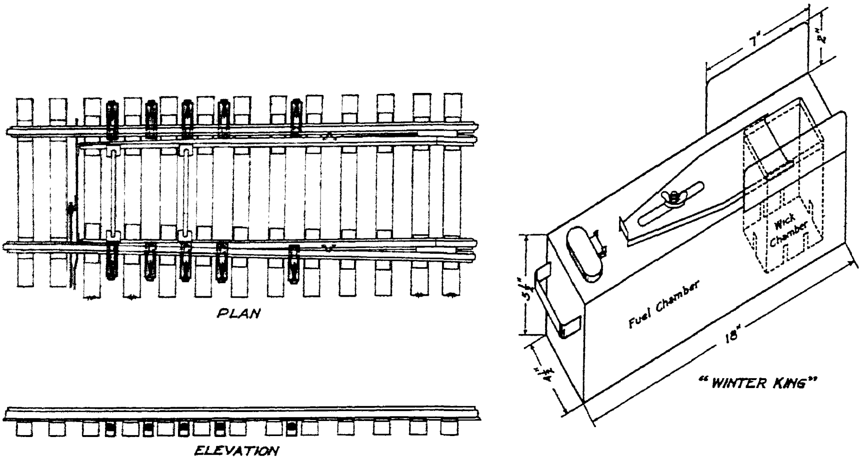

FIG. 5.—WINTER KING SNOW MELTER.

Snow-melting devices, numbers 10 to 18, are classed as fixed, because they are normally installed in the fall and removed in the spring. However, some of the electric melters are left in place the year round. The cost of equipment, installation and operation of fixed melters, is usually higher than other types, but as a rule they require less attention during operation.

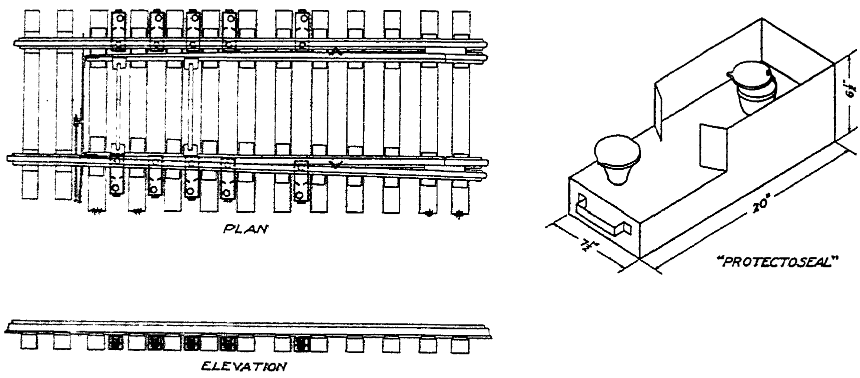

FIG. 6.—PROTECTOSEAL SNOW MELTER.

10. Steam coils are laid between the switch ties with proper slope to provide drainage. Water produced by melting the snow flows from the roadbed to catch-basins connected with sewers and this also takes care of the condensation. Steam is furnished from heating plants or locomotives specially equipped. Where sufficient steam is readily procurable, this is probably an economical method of melting snow. However, since the

pipes must be laid with sufficient fall to drain the condensed steam, this may result in the low end of the coil being so deep as to render it useless as a snow melter (Fig. 7).

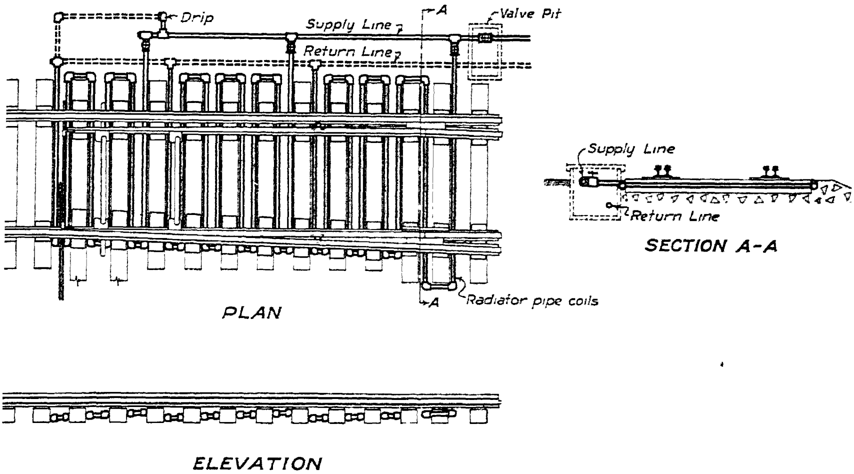

FIG. 7.—STEAM COILS UNDER SWITCH.

11. Perforated steam pipes in concrete pits with necessary drains are used to melt snow cleared from the tracks, etc., and shoveled or dumped into the pits. When not in use, the pits are covered with steel lids (Fig. 8).

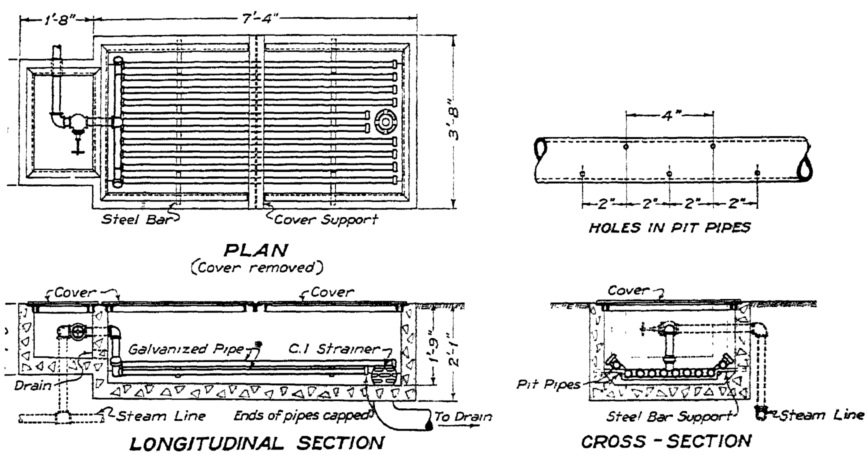

FIG. 8.—STEAM PIPES IN PIT.

12. The Greer oil burning melter is of the intermittent spraying type. The oil is sprayed only for short periods about once an hour, the interval depending somewhat on the severity of the storm. The spray is turned on and off intermittently by the attendant at a valve adjacent to the installation. This device is designed especially for use of highly inflammable, low-flash oil, preferably casing-head gasoline, snow-melting oil, or low pressure hydro-carbon oil. The supply is stored in a tank elevated at least 10 ft., or in a pit where air pressure causes it to flow. About 1 to 1.5 gallons is required per

hour per switch and the flaming oil is sprayed on the parts to be freed of snow. An installation at a switch consists of two short lines of half-inch pipe laid parallel to and on the outside of the rail and mounted on brackets. These small pipes are connected by a one-inch pipe which has an insulated union and which in turn is connected to the supply line. Each of the pipes is equipped with five or more spray nozzles which are so arranged that they discharge the oil directly against the rail in the form of a fine spray, which ignites readily. The igniters consist of small oil wells with projecting wicks, over which the oil is sprayed by special nozzles. They are located at the ends of the pipes, so that the oil discharged from all the nozzles is lighted instantly (Fig. 9).

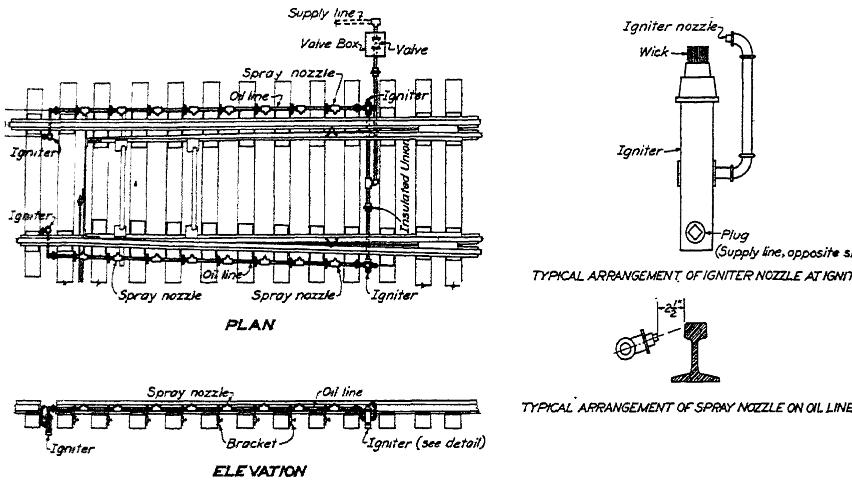

FIG. 9.—GREER OIL BURNING SNOW MELTER.

13. The Chausse oil burning snow melter is of the constant burning type. Usually 5 ft. of 2 in. pipe perforated with one-half inch holes at 4 in. intervals is attached to each end of a tee connection at the burner. While the total length of the unit is usually about 11 ft. (including the tee at the burner) installations up to 20 ft. long have been used, and where clearance or other conditions require, the burner may be installed at one end of the unit rather than at the center. There is one unit placed along the outside of each rail at a switch, the pipes are held in place by brackets attached to the ties and there is a spacer deflector between the heater and the rail head. Two models of this device are manufactured, one with a self-generating vaporizing burner, while the other is furnished with a vacuum type of atomizer burner (Fig. 10).

The self-generating type burns kerosene and requires this fuel under a pressure of 20 to 25 lb. per sq. in. This pressure may be secured either by a pump in the fuel line (a one-quarter horse-power motor driven pump is sufficient to supply 100 burners or 50 switches) or by compressed air on the fuel in the tank. Because of the high pressure required, it is impractical to elevate the fuel tank to secure the necessary head (over 50 ft.). Each burner, or generator, must be heated with a torch for from two to three minutes to start generation of gas. About 1.25 gallons of kerosene is consumed by each burner unit per hour. Being of the generating type, this burner is subject to carbonization especially if insufficient pressure is maintained.

The general layout for the model furnished with the vacuum type burner is very similar to the above. The burner requires about 2 cu. ft. of air per minute at a pressure of over 25 lb., but not exceeding 100 lb., and burns from one-half to three-quarters

gallons of low grade fuel such as distillate or furnace oil per hour. This fuel should be under a head of one or two feet. No preheating of the burner is necessary and there is no trouble encountered from carbonization, or from dirt or water in the fuel oil.

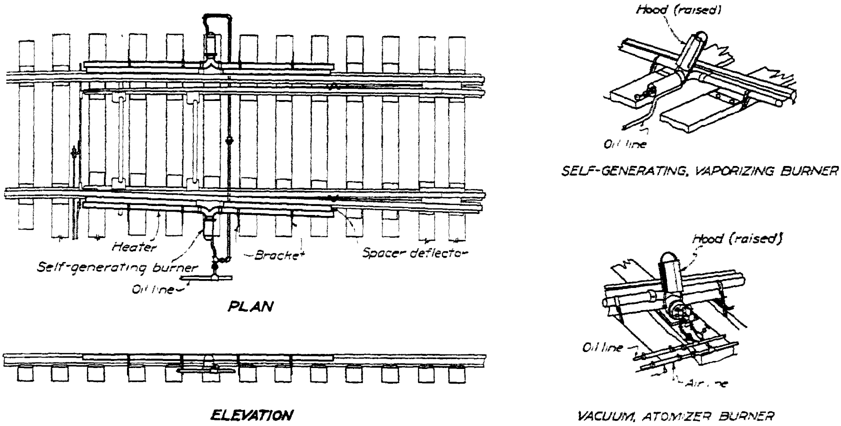

FIG. 10.—CHAUSSE OIL BURNING SNOW MELTER.

14. A Vaughan gas burning snow melter unit consists of two gas burners connected together by a small pipe. Each unit is placed between the ties, and is ordinarily clamped to the rail base and one end of the unit is attached to a manifold running parallel to and outside of the track by means of short lengths of hose or piping. In cases where it is inconvenient to clamp the unit to the rail base, it may rest on the ground or on an improvised support, and for slip switches four or more burners may be attached to each unit. The units in all cases are so placed and the burners spaced so that each burner is under part of the rail base and the switch point on a closed switch. Towards the point of the switch the units are usually placed between each tie, while towards the heel they may be placed in alternate tie spacings or omitted entirely, depending on the severity of snows likely to be dealt with. Each burner of a unit consumes on an average about 12.5 cu. ft. of gas per hour, and is lighted by hand. The heat may be regulated to meet any condition from a light snow to a blizzard, but the rails seldom attain a temperature of over 125 degrees. These snow melters are being extensively used (Fig. 11).

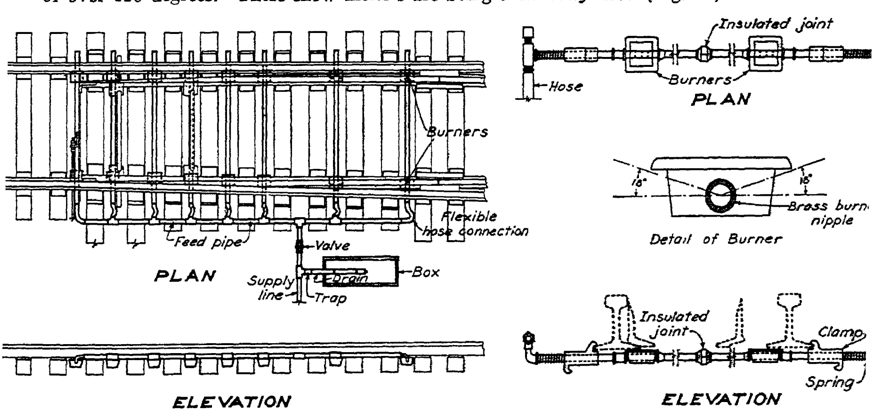

FIG. 11.—VAUGHAN GAS BURNING SNOW MELTER.

15. The Chausse electrically ignited gas burning snow melter consists of a perforated brass pipe placed within a steel angle which serves as a heat distributor, deflecting the flame and heat towards the web and the base of the rail. The gas pipe is perforated at 3 in. intervals and is connected to the gas main at one end. The heat deflector consists of a 15 ft. length of a steel angle which is located adjacent to the lower edge of the ball of the rail and held in place by adjustable brackets attached to the ties. A nichrome wire electrical ignition coil is placed at the center of each unit. Each heater burns about 100 cu. ft. of gas per hour or 200 cu. ft. for the switch, and each ignitor consumes about 225 watts or 450 watts for the switch. The melter burns with an invisible flame, which insures against interference with signals. The main gas valve and the main electric switch may be placed at some convenient point such as at a signal tower. The melters may be turned on periodically or left on continuously (Fig. 12).

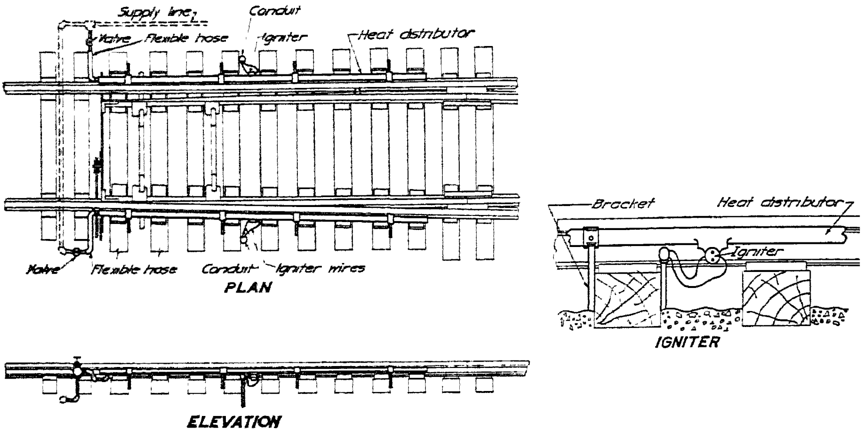

Fig. 12.—Chausse Gas Burning Snow Melter.

A few remarks apply to all types of electric snow melters, numbers 16 to 18 inclusive. They may all be controlled from a central point without hazard to the attendant. Advantage is obtained over the storm in that the heat may be started quickly at the first indication of its approach. They are clean, do not obscure signals, and are easily operated. Furthermore, they may be used where high winds would extinguish heaters of the open flame type, and at locations where the latter would create a hazard to the rolling stock or contents thereof. In third rail and other territories, where electric current is cheaply obtained in sufficient amounts, these heaters have proven successful, but where such is not the case, the high cost of operating them combined with their high initial cost, have militated against them. Other minor disadvantages are that induced currents may interfere with signal circuits and it is difficult to determine from a casual examination whether a unit is in operation or not. In the sealed types, precaution must be exercised to see that they remain sealed for should moisture enter the housing, the rapid vaporization, which takes place when the current is turned on, may cause them to blow up. There are numerous designs of electric melters, separated into three general types; namely, radiation, contact, and combination radiation and contact. As a rule the manufacturer will furnish heating elements to operate on any desired voltage and to draw the current necessary to develop the heat required.

16. The radiation type consists of a heating coil placed in a housing, which is placed under the rail between the ties, usually laid on the ballast. The heat radiated from the unit serves to heat the surrounding space, melting any snow or ice within the

heated zone. These melters are easily placed and operated, but do not make the best use of the heat generated, a big part of this heat being dissipated into the ballast and atmosphere.

(a) Westinghouse. Consists of a steel pipe casing sturdy enough to resist damage caused by striking with a pick or shovel. The heating element is a nickel chromium helical coil placed in grooves in heavy refractory brick, which are held in rust-proof metal saddles. The unit is placed in the ballast so that the top is about one inch below the rail. Each unit consumes about 1250 watts.

(b) The Hevi-Duty melter is similar to the Westinghouse above, in appearance, but each unit draws 750 watts. A long sheet steel hood is placed over the ties on the outside of the track, one edge of the hood fitting fairly close to the head of the rail and extends for the entire length of the installation. This hood is intended to aid in confining as much of the heat as possible to the rail (Fig. 13).

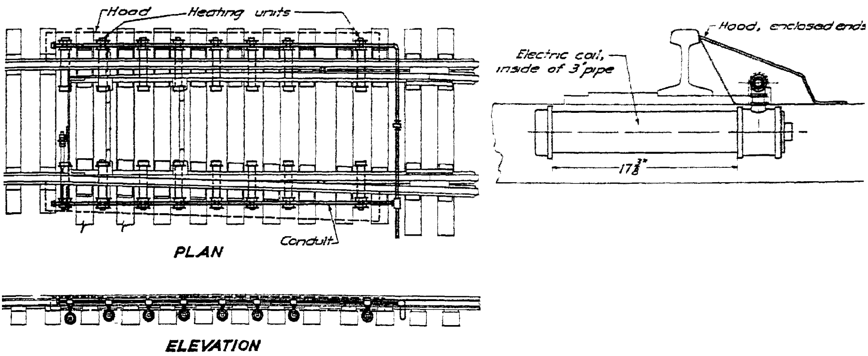

Fig. 13.—Hevi-Duty Radiation Electric Snow Melter.

(c) Q & C consists of a heating element in a cast iron box about 18 in. long, 6 in. wide and 1.5 in. thick. Each unit consumes 1000 watts and is furnished for either 47 or 55 volts, allowing the units to be placed in series or series parallel depending on the line voltage supplied. They attain a temperature of 284 degrees Fahr., in fifteen minutes and a maximum of 650 degrees in approximately an hour (Fig. 14). This same design is also made in a 36 in. length, drawing the same current. It is intended for use around slip switches and other locations where the points to be protected are relatively close together, but still far enough apart to necessitate, otherwise, the use of two of the shorter units.

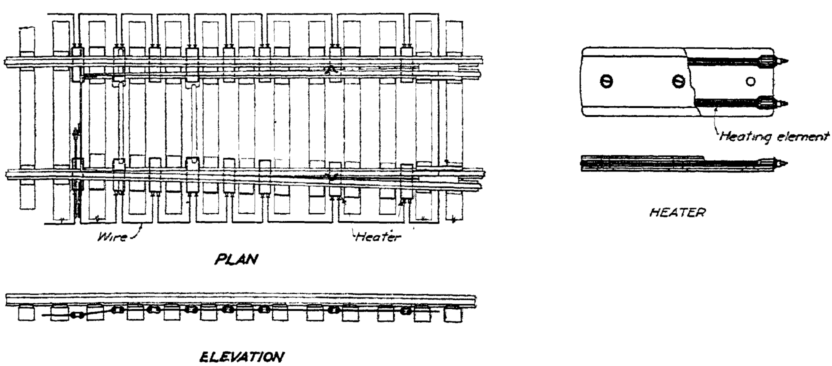

Fig. 14.—Q. & C. Radiation Electric Snow Melter.

(d) Westinghouse. This design is similar to the Q & C described above. Each unit draws 750 watts.

(e) The G & R melter is cylindrical in shape and is equipped with a large number of radiation rings or fins, which have a total radiation surface of approximately 6 sq. ft. Its heating unit is wired for 110 volts and draws 1000 watts. It is designed to withstand vibration and moisture (Fig. 15).

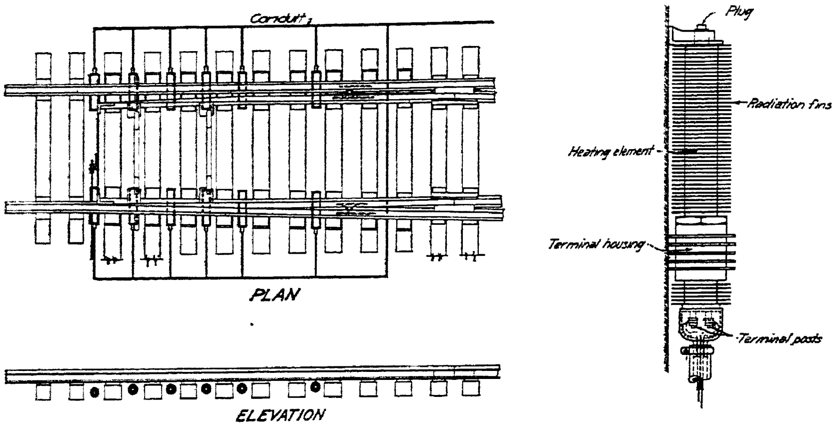

Fig. 15.—G. & R. Electric Radiation Snow Melter.

(f) Westinghouse. This unit is designed to be fastened to the side of the cross-tie by a bracket. The unit consists of a nickel chromium helical coil placed in grooves in a porcelain block supported by clips in a malleable iron box. There is a layer of insulating material at the bottom of this box which serves to retard any radiation of heat downward. The heat element is designed for 55 volts and draws 750 watts (Fig. 16).

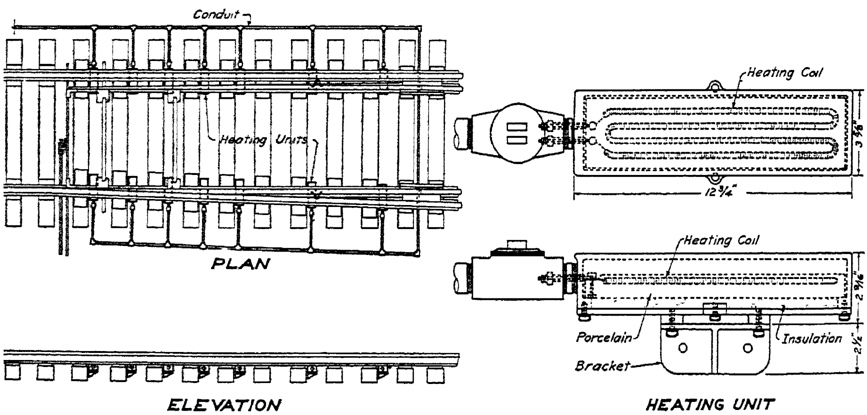

Fig. 16.—Westinghouse Electric Radiation Type Snow Melter.

(g) The Hot Shot melter furnishes air heated electrically. A number of electrically heated units are connected by a system of ducts to a one-third horsepower motor driven blower. Air from the blower passes through the heating units and is heated to a high temperature before it passes through the orifices in the upper side of the heating

unit housing. The heaters and ducts are buried in the ballast. One large blower may be used to operate a number of installations. The blower may be located some distance away as in a tower or if suitable air supply is available no blower is required. The temperature of the air three-quarters inch from the orifice runs about 300 degrees Fahr. The units are wired for 110 or 220 volts and each unit consumes 500 watts. The orifices are bushed with brass to prevent them from closing up due to corrosion. The unit is placed so that this orifice is directly under the space between the rail and the switch point (Fig. 17).

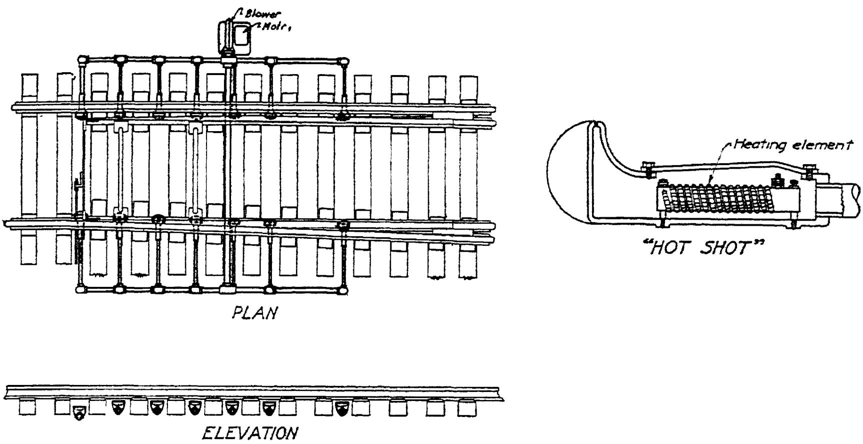

FIG. 17.—HOT-SHOT RADIATION ELECTRIC SNOW MELTER.

17. In the contact type of electric melters the heating unit is usually placed snug against the web of the rail, as in the case of the tubular designs, or snug against both the web and the upper surface of the rail base as in the case of the box designs. However, there is one unit designed to be placed in a recessed space in the tie under the slide plate directly under the base of the stock or turnout rail. All of them are designed primarily to heat the rail—any radiation from the heater being incidental. This type of melter is more economical to operate than the radiation type. There is less heat dissipated into the atmosphere and none into the ballast, while more heat reaches the rail and slide plates. As a rule melters of the contact type are more difficult to install and dismantle than either the radiation type described above or the combination contact and radiation type described later. In some cases, they are left in place the year around.

(a) Elec-TraC is of the box design, consisting of a copper bearing pressed steel frame or housing which fits up against the web of the rail, in which is mounted an asbestos insulator with an enclosed tubular heating element protected by a stainless steel covering. Each unit is about a foot long and is installed on the outside of the rail between the ties. The units are wired for 110 volts and draw 600 watts each (Fig. 18).

(b) The Q & C is a tubular design, fastened to the inside web of each rail at a switch by small clamp bolts extending through the web. The tube is fairly flexible, permitting it to be bent and placed close to the head or base of the rail to dodge obstructions, such as stops or bolt heads in the switch point. The most used design is a single tube with a continuous heating element throughout the length of the unit. The wattage of each unit is from 3600 to 6000 depending upon the length of the switch and the temperature required. Since there is no provision for the return of the current within the unit, it is necessary to bring the end towards the heel of the switch out through a hole

in the web of the stock rail, for a connection with the feeder circuit, unless a small conduit is placed alongside the heating unit.

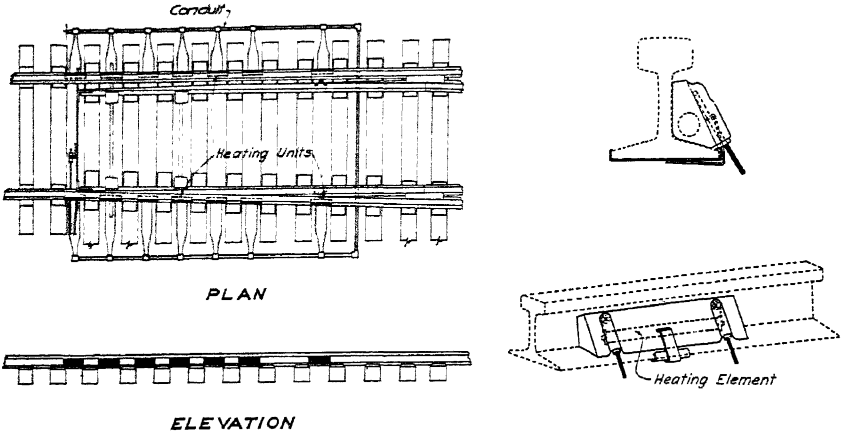

FIG. 18.—ELEC-TRAC CONTACT ELECTRIC SNOW MELTER.

Another model consists of twin tubes in which heating units about 12 in. long are centered over each tie. This twin unit has a total width of 1.25 in. and is made from 0.49 in. diameter tubing flattened to 0.36 in. on the side that contacts the rail. Like the single tube, this unit is flexible, and where necessary the two tubes may be separated. Since the tubes are connected to each other at the heel end, one tube serves as a return for the other, simplifying the connection to the feeder circuit. Each heating unit draws about 500 watts (Fig. 19).

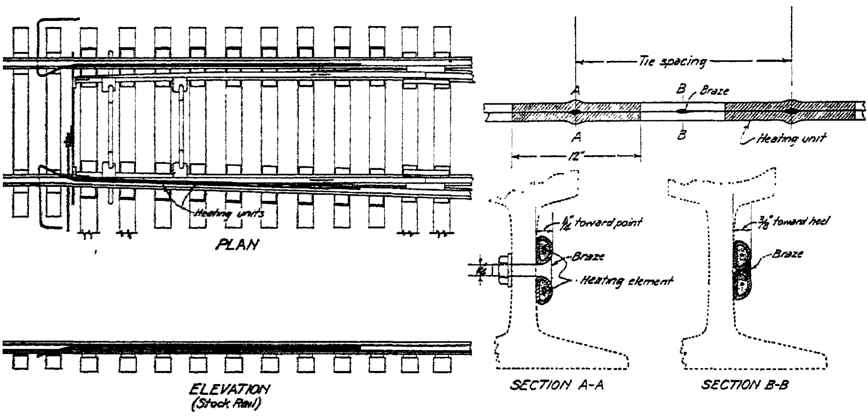

FIG. 19.—Q. & C. CONTACT TUBULAR ELECTRIC SNOW MELTER.

(c) Westinghouse. Similar to the above, except that though they do make the twin tubular in the spaced heat design, their standard design for both the single and twin types provides for a continuous heating element throughout the length of the unit.

(d) B & H. This is a twin tubular design similar to the spaced heat design described, but each heating element draws 375 watts.

(e) Keim. This device applies the heat from 500 watt elements to the outside web of the stock rails. Each element is 12.5 in. long and secured over the space between ties by clamps engaging the underside of rail base, for the length of the switch points. Tests made of these heaters in service show that they are capable of raising the temperature of the rail at the center of the heater 15 degrees in the first 15 min., 65 degrees in 45 min., 75 degrees in one hour, and 125 degrees in two hours (Fig. 20).

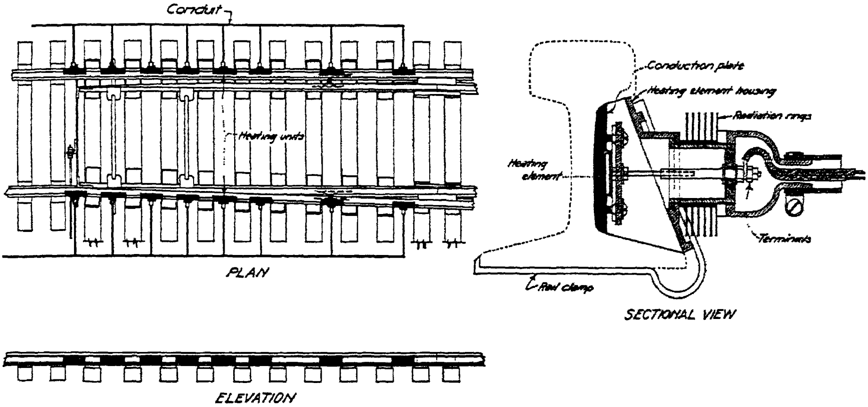

FIG. 20.—KEIM CONTACT ELECTRIC SNOW MELTER.

(f) B & H tie plate design. This device consists of a heating element laid in an open top corrugated steel box which is inserted in an aluminum trough placed in a recessed space in the tie under the slide plate and directly under the running rail. This trough facilitates installation and withdrawal of the unit and because of the heat reflecting properties of aluminum, tends to diminish charring of the tie (Fig. 21).

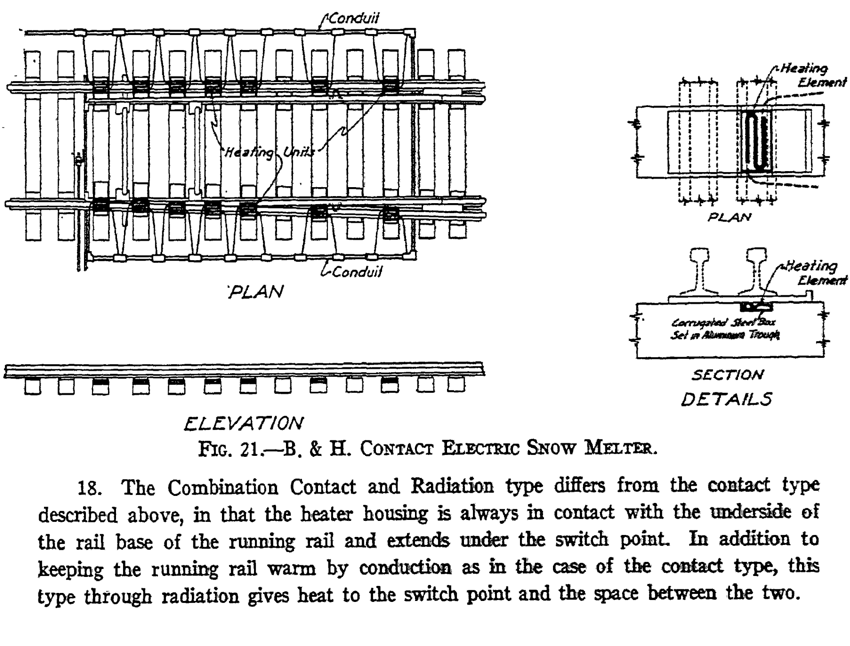

FIG. 21.—B. & H. CONTACT ELECTRIC SNOW MELTER.

18. The Combination Contact and Radiation type differs from the contact type described above, in that the heater housing is always in contact with the underside of the rail base of the running rail and extends under the switch point. In addition to keeping the running rail warm by conduction as in the case of the contact type, this type through radiation gives heat to the switch point and the space between the two.

(a) Q & C. The general design of this type is similar to the Q & C radiation type, but it has a flat space along the top of the housing for contact with the entire width of the rail base of the running rail to which it is attached by means of a clamp, which comes over the rail base. It is placed between the ties and requires 500 watts (Fig. 22).

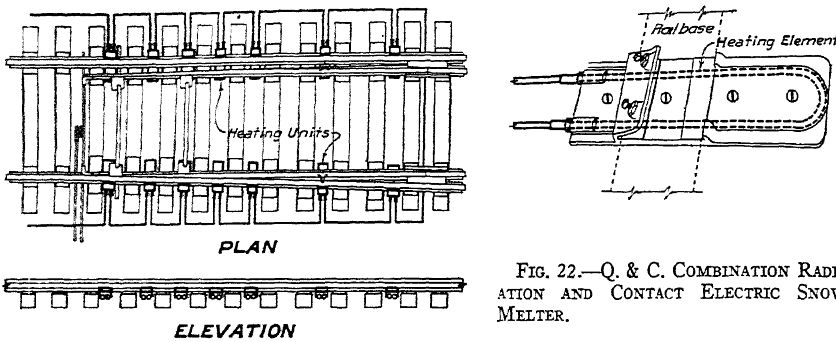

FIG. 22.—Q. & C. COMBINATION RADIATION AND CONTACT ELECTRIC SNOW MELTER.

(b) Westinghouse. Similar to the above, except that the unit draws 750 watts (Fig. 23).

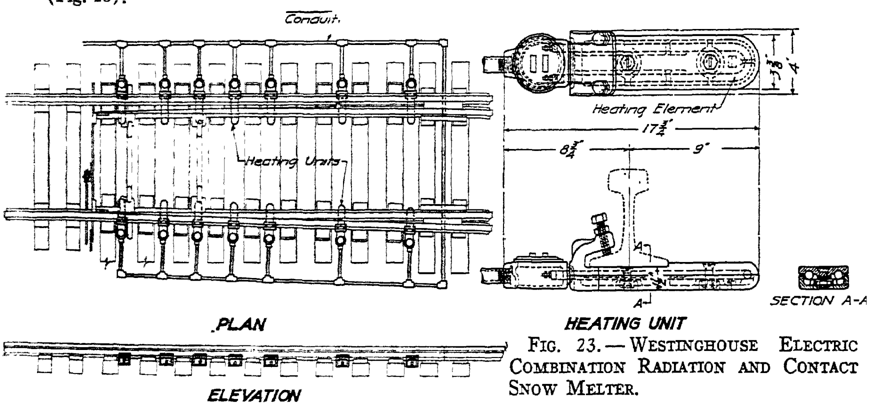

FIG. 23.—WESTINGHOUSE ELECTRIC COMBINATION RADIATION AND CONTACT SNOW MELTER.

(c) B & H. Similar to the above, but the housing is shorter so that it is in contact with only half of the width of the rail base, but extends the same distance under the switch point. It requires 425 watts per unit (Fig. 24).

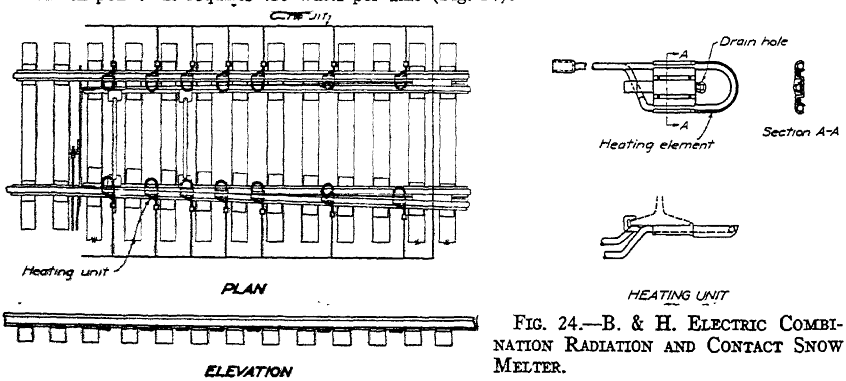

FIG. 24.—B. & H. ELECTRIC COMBINATION RADIATION AND CONTACT SNOW MELTER.

Manufacturers or Distributors of Above Devices

"Nivosal"	Monmouth Chemical Corporation, 140 Cedar Street, New York, N. Y.
"Greer"	The Howard P. Cook Company, 945 Main Street, Bridgeport, Conn.
"Protectoseal"	Protectoseal Company, 1906–24 So. Western Ave., Chicago, Ill.
"Buckeye"	The MacLeod Company, 2232–40 Bogen Street, Cincinnati, Ohio.
"Chausse"	Chausse Oil Burner Company, 1227 W. Beardsley Ave., Elkhart, Ind.
"Hauck"	Hauck Manufacturing Company, 126–134 Tenth Street, Brooklyn, N. Y.
"Littleford"	Littleford Bros., 444 E. Pearl Street, Cincinnati, Ohio.
"Mahr"	Mahr Manufacturing Company, 6 No. Michigan Avenue, Chicago, Ill.
"Unique"	Unique Manufacturing Company, Inc., 221 West Whiting Street, Chicago, Ill.
"Fairmont"	Fairmont Railway Motor, Inc., 80 E. Jackson Blvd., Chicago, Ill.
"Woolery"	Woolery Machine Company, Minneapolis, Minn.
"Servrite"	Service Supply Corporation, 20th E. Venango St., Philadelphia, Pa.
"Winter King"	Bethlehem Steel Company, 400 No. Michigan Avenue, Chicago, Ill.
"Vaughan" "G & R" "Keim"	Ruby Railway Equipment Company, Real Estate Trust Building, Philadelphia, Pa.
"Westinghouse"	Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.
"Hevi-Duty"	Hevi-Duty Electric Company, 4212 W. Highland Blvd., Milwaukee, Wis.
"Q & C"	The Q and C Company, 90 West Street, New York, N. Y.
"Hot Shot"	Louisville Switch & Signal Company, Louisville, Kentucky.
"Elec-TraC"	Electric Service Supplies Company, Philadelphia, Pa.
"B & H"	Horne Equipment Corporation, 90 West Street, New York, N. Y.

Railroads Using Various Types

Table 1 was compiled from information secured from a canvass of railroads in the United States, which are affected by snow and from Canadian roads, also from manufacturers of snow-melting devices. It was made as extensive as possible account of the great number of devices available and also to define what territory geographically is being served with snow melters. Where there was any conflict in data received from these sources, the railroad's reply was used. Where a road did not reply to the canvass, the manufacturer's information was accepted. A few roads replied that they are not using any snow-melting devices and all such reporting roads are included. Information from the road itself or from manufacturers was secured for all roads addressed, except about 10 per cent, and these have not been included in the table.

TABLE 1.

Railroad	Chemicals	Portable: Snow-Melting Cans	Portable: Torches	Portable: Weed Burners	Portable: Steam Jets on Locomotives	Semi-Portable Oil-burning Pots	Fixed: Steam Coils under Switches	Fixed: Steam Pipes in Pits	Fixed: Oil Melters	Fixed: Gas Melters	Fixed: Electric Melters
Akron, Canton & Youngstown	x	...	...	...	...	x	...	...	...	...	...
Atchison, Topeka & Santa Fe	x	x	x	...	x	x	...	...	...	...	...
Baltimore & Ohio	x	...	x	...	...	x	...	...	...	...	...
Baltimore & Ohio Chicago Terminal	x	...	...	...	x	...	...	...	...	...	...
Bangor and Aroostok	...	...	...	...	...	...	...	x	...	...	...
Belt Ry. of Chicago	x	x	x	...	x	x	...	...	...	...	...
Bingham & Garfield	x	...	...	...	...	...	...	...	...	...	...
Board of Transp.Subway,New York ..	...	...	...	...	...	...	...	...	...	...	x
Boston & Albany	...	...	...	...	...	x	...	...	x	...	...
Boston and Maine.................	x	x	...	x	x	x	...	...	x	x	x
Boston Rapid Transit	...	x	...	...	...	...	...	...	...	...	...
Buffalo, Rochester and Pittsburgh	x	...	x	...	...	x	...	...	...	...	...
Canadian National	x	x	...	...	...	...	...	...	...	...	...
Canadian Pacific	x	x	x	x	x	x	x	...	...	...	...
Central of New Jersey............	x	x	...	...	x	...	x	...	...	...	...
Central Vermont	...	...	...	...	...	...	...	...	...	...	...
Chesapeake and Ohio	...	...	x	...	...	x	...	...	...	...	...
Chicago and Eastern Illinois	...	...	x	x	...	...	...	...	x	...	...
Chicago & North Western	x	x	...	...	x	x	...	...	...	x	...
Chicago & Western Indiana	...	x	...	...	...	x	...	...	...	...	...
Chicago, Aurora and Elgin	x	...	...	...	...	x	...	...	...	...	x
Chicago,Burlington & Quincy	x	x	x	...	x	x	...	...	...	...	...
Chicago Great Western	x	...	...	...	...	...	...	...	...	...	...
Chicago,Indianapolis & Louisville	x	x	...	...	x	x	...	...	x	...	...
Chicago,Milwaukee,St.Paul and Pac.	x	...	x	x	x	x	...	x	...	x	...
Chicago Rapid Transit	...	...	x	...	...	x	...	...	x	x	...
Chicago,Rock Island & Pacific	x	...	...	...	x	x	...	...	...	x	...
Chicago,South Shore and South Bend	x	...	x	...	...	x	...	...	...	x	x
Chicago Union Station	...	...	x	...	...	x	...	...	...	x	...
Cleveland,Cinti,Chicago & St.Louis	...	...	...	...	...	x	...	...	...	...	...
Cleveland Union Terminal	...	...	...	...	...	...	...	...	...	...	x
Colorado & Southern	...	...	...	...	...	...	...	...	...	...	...
Conemaugh & Black Lick	...	...	...	...	x	x	...	...	...	...	...
Delaware and Hudson	x	x	x	...	...	x	...	x	...	...	...
Delaware,Lackawanna & Western	x	x	...	...	...	x	x	...	x	x	...
Denver and Rio Grande Western	x	...	...	...	...	...	...	...	...	...	...
Denver and Salt Lake	...	...	...	...	...	...	...	...	...	...	...
Detroit and Toledo Shore Line	x	...	x	...	...	x	...	...	...	...	...
Duluth,Misabe & Northern	x	...	...	...	...	...	...	x	...	...	...
Duluth,South Shore & Atlantic	x	...	...	x	x	...	...	x	...	...	...
Elgin,Joliet and Eastern	x	x	x	...	x	x	...	...	...	x	...
Erie	x	x	x	...	x	x	x	...	...	x	x
Genesee and Wyoming	x	...	...	...	...	...	...	...	...	...	...
Great Northern	x	...	...	...	...	...	...	...	...	...	...
Illinois Central	x	...	x	x	x	x	x	x	...	...	x
Illinois Terminal	...	...	...	...	...	x	...	...	...	...	...
Indiana Harbor Belt	x	...	...	...	x	x	x	...	x	...	x
Indianapolis Union	x	...	x	...	...	...	...	...	...	...	...
Kansas City Southern	...	...	...	...	...	x	...	...	...	...	...
Kansas City Terminal	...	...	...	...	...	x	...	...	...	...	...

Railroad	Chemicals	Portable: Snow-Melting Cans	Portable: Torches	Portable: Weed Burners	Portable: Steam Jets on Locomotives	Semi-Portable Oil-burning Pots	Fixed: Steam Coils under Switches	Fixed: Steam Pipes in Pits	Fixed: Oil Melters	Fixed: Gas Melters	Fixed: Electric Melters
Lehigh and New England	x	...	x	...	....	...	...	...	...	...	...
Lehigh Valley	...	...	x	...	....	x	...	...	...	...	...
Maine Central	x	x	x	...	....	x	...	...	...	...	...
Michigan Central	x	...	...	...	....	x	...	...	...	...	...
Milwaukee Electric	x	...	...	...	....	x	...	...	...	...	x
Minn.,St.Paul & Sault Ste.Marie	x	...	...	...	x	...	x	x	...	...	...
Minnesota Transfer	...	...	...	x	...	...	...	...	...	...	...
Missouri-Kansas-Texas	...	...	...	...	...	...	...	...	...	...	...
Missouri Pacific	...	...	x	...	...	...	...	...	...	...	...
New York Central	x	x	...	...	x	x	...	...	x	...	x
New York,Chicago and St.Louis	x	x	x	...	x	x	...	...	...	...	...
New York,New Haven and Hartford	...	x	...	...	...	x	...	...	x	...	x
Niagara Junction	...	...	...	...	...	x	...	...	...	...	...
Norfolk and Western	...	...	...	...	...	x	...	...	...	...	...
Northern Pacific	x	...	...	...	...	...	...	...	...	...	...
Pennsylvania	x	x	x	x	x	x	...	x	x	x	x
Pittsburgh & Lake Erie	x	...	x	...	...	...	...	...	...	...	...
Pittsburgh & West Virginia	x	...	...	...	...	...	...	...	...	...	...
Reading	...	...	x	...	...	x	...	...	...	x	...
Richmond,Fredericksburg & Potomac	x	...	x	...	...	...	...	...	...	...	...
Rutland	...	...	...	...	...	...	...	...	...	...	...
Salt Lake & Utah	x	...	...	...	...	...	...	...	...	...	...
South Buffalo	...	...	...	...	...	x	...	...	...	...	...
Southern	x	...	...	...	...	...	...	...	...	...	...
Southern Pacific	...	...	...	...	...	...	...	...	...	...	...
Spokane,Portland and Seattle	x	...	...	x	...	...	...	...	...	...	...
Steelton & Highspire	...	...	...	...	...	x	...	...	...	...	...
Terminal R.R.Assoc.of St.Louis	...	...	...	...	...	x	...	...	...	...	...
Toledo,Peoria & Western	...	...	...	...	x	...	...	...	...	...	...
Toledo Terminal	x	...	...	...	...	...	...	...	...	...	...
Union Pacific	...	...	...	...	...	...	...	...	...	...	...
Wabash	...	...	...	...	x	x	...	...	...	...	...
Washington Terminal	...	x	...	...	x	...	...	...	...	x	...
Western Maryland	...	...	x	...	...	x	...	...	...	...	...
Western Pacific	x	x	...	...	...	...	...	...	...	...	...
Wheeling and Lake Erie	x	...	...	...	...	...	...	...	...	...	...

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Snow-melting, hydro-carbon burners, steam blowing locomotives, snow-melting pits and snow-melting gondolas.

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Method of equipping locomotives and their use for blowing snow.

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19. Railway Age,
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Vol. 26, Page 467, October, 1930.
Description of Improved Keim contact type and G.R. radiation type, of electric snow melters. Illustrated.

24. Electric Journal,
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Description of two electric snow melters, one a contact type and the other a radiation type. Illustrated.

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Vol. 26, Page 570, December, 1930.
Description of Chausse gas burning snow melter equipped with electrical igniter. Illustrated.

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Vol. 27, Page 61, January, 1931.
Description of Nivosal, a snow-melting chemical.

27. Railway Engineering and Maintenance,
Vol. 27, Page 269, March, 1931.
Design of Hot Shot electric radiation type snow melter. Illustrated.

28. Railway Engineering and Maintenance,
Vol. 27, Pages 354 to 356, April, 1931.
Use of various types of snow melters in the Chicago area during a severe blizzard, and their economy as compared to manual methods of snow removal.

29. Railway Engineering and Maintenance,
Vol. 27, Page 386, April, 1931.
Description of Elec-TraC contact type electric snow melter. Illustrated.

30. Railway Age,
Vol. 91, Pages 542–544 incl., October 10, 1931.
Use and economy of various types of snow melters in the Chicago area and a few eastern locations.

31. Railway Engineering and Maintenance,
Vol. 27, Pages 956–960, November, 1931.
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Vol. 27, Pages 964–967, November, 1931.
Use and economies of various types of snow melters during recent blizzards in the Chicago area.

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Vol. 28, Pages 34–35, January, 1932.
Use of pneumatic ice picks on the Canadian Pacific at locations where heavy snows and prolonged cold weather make snow melters ineffective.

Conclusions

Under proper conditions, snow-melting devices are an aid in facilitating train operation and reducing maintenance expense. There are many different types available. The best type and design for the purpose is worthy of some study.

Appendix C

(5) USE AND ADAPTABILITY OF TRACK TYPE TRACTORS IN MAINTENANCE OF WAY WORK

T. M. Pittman, Chairman, Sub-Committee; G. A. W. Bell, Jr., W. O. Cudworth, J. S. Huntoon, R. H. Kugler, R. A. Morrison, J. G. Sheldrick, H. W. Stetson, J. B. Trenholm, G. R. Westcott.

General Description

There are two general types of tractors, the wheel type and the track type. The wheel type is mounted on four wheels, two small ones in front and two of wide tread and large diameter behind. In most tractors of this type, the rear wheels carry most of the weight and furnish all of the traction but some are now being made with driving power applied to all four wheels. The inability of this machine to work in soft ground on account of the wheels bogging led to the development of the track type tractor which is now extensively used in many branches of industrial, agricultural and construction work and which is generally referred to as the caterpillar or crawler type tractor.

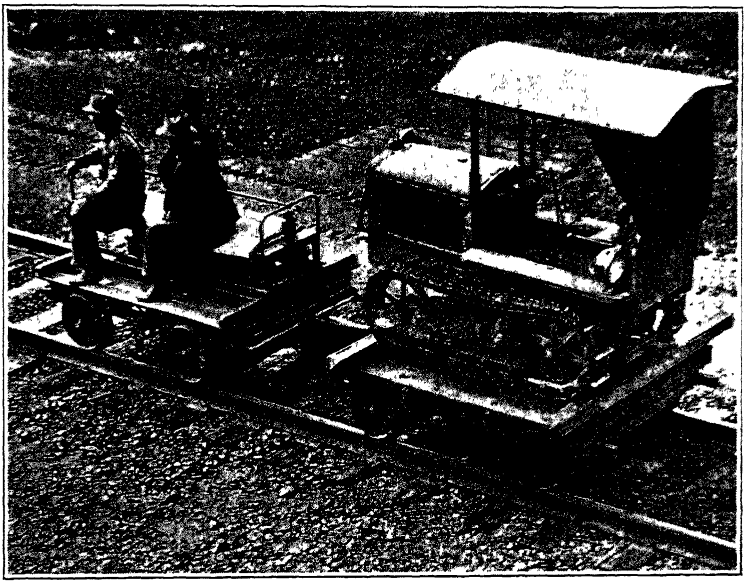
The track type tractor was first developed to meet the demand for a tractor for agricultural purposes in the soft soil of delta countries where the wheel type tractors would bog, even when rear wheels of extremely large diameter and width were used. The idea originated from the principle of the tread mills in general use on the farms of the earlier days, and in 1905 the first machine of the track type was perfected. This crude machine, built largely of scrap material and powered with a steam boiler, has been developed and improved until these tractors are now standard products of several factories and range in size from 10 H.P. to 90 H.P. at the drawbar. Most of these machines are powered with gasoline motors, although in some cases kerosene has been used, and one large manufacturer is now powering their large machines with Diesel engines. Experience with this type motor has been very satisfactory and points to a more extended use of the Diesel engine in the future.

The most distinctive feature of the track type tractor, from which it derives its name, is the method by which it lays a track to run on and picks it up and carries it forward after the machine has passed over it. Instead of running over a fixed track as does a locomotive, the tractor rolls over a flexible track which it picks up and lays down ahead of the rollers and drive wheels, thereby providing the tractive advantages of a steel track without the limitations of a track in a fixed location.

The track consists of track shoes, links, pins and bushings, which when assembled form a continuous chain or flexible belt. The shoes may be flat to run on pavements or provided with lugs or grousers for operating over soft ground. There are also special shoes for use on snow and ice, and rubber-surfaced shoes for use on the floors of buildings. The weight of the machine is carried on this track by rollers extending the entire length while the driving power is applied by a large sprocket wheel at the rear, over which the track passes. As the rollers of the machine pass over the track, the sprocket wheel picks it up and carries it forward over a large idler wheel at the front end of the machine where it is laid down to receive the rollers again. By this means the weight of the tractor is so distributed that the bearing pressure on the soil is only about 5 or 6 pounds per square inch for the sizes most suitable for railroad work, even though the weight of the machines themselves runs from 5,000 to 10,000 lb. This pressure may be decreased by the use of wider shoes which can be applied to the standard track chain. This bearing pressure is about the same as that of an average man standing on one foot.

The ease with which these machines can be handled and their flexibility of operation is also an important feature. They respond instantly to the controls and can be turned

completely around in their own length. Due to the low bearing pressure they can operate over snow and bad roads, over soft ground where there are no roads and through shallow water and swamps. They can travel down a railroad track by placing one tread between the rails and the other on the ends of the ties, and can cross an open deck trestle or through plate girder bridge of standard gage track. They can climb a grade of 1½:1 with ease and their low center of gravity provides a large factor of safety against overturning. They will travel at a speed of about 3½ miles per hour in high and 2 miles per hour in low gear, but can be equipped for higher speeds if desired.



Moving a Track Type Tractor on a Push Car.

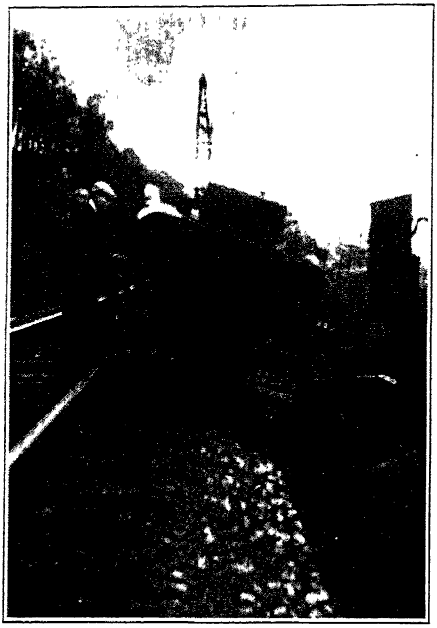
The flexibility of operation of the machine and its rugged construction has led to its wide use in levee and highway construction and in many industries and agriculture. Over 10,000 were used by the Allied armies during the late World War and they have since been adopted as standard for use by the United States Army.

The sizes best suited to railroad work are the medium sizes of 15 to 30 H.P. These sizes have sufficient power to handle a good sized load of dirt and are small enough to operate in narrow clearances and may be loaded easily for moving from one job to another.

The cost of operation, including one operator, is from $8 to $15 per day, depending upon the size of the machine and the character of work being done. The gasoline consumption will range from 1½ to 3 gallons per hour.

Auxiliary Equipment

Although many uses can be found in maintenance of way work for the standard tractor by itself, the development of attachments for performing special classes of work is of greater interest to the railroads. There are a number of such attachments manufactured by independent concerns but designed for use with tractors of certain makes and models. Most of these were designed largely for uses outside of maintenance of way



Track Type Tractor Passing by a Signal and Over the Conduit.

work and consequently such work must be adapted to the possibilities of the attachments. Although many of these attachments can be used to very good advantage on railroad work, a greater interest on the part of the railroads will no doubt result in the develop-

Track Type Tractor Moving Over an Open Deck Trestle.

Showing Track Type Tractor Operating at a 45 Degree Angle.

ment of attachments designed to meet the specific needs of maintenance of way work. These attachments can be easily and quickly removed and others applied, and under these conditions, the tractor virtually becomes a power plant of rugged construction, flexible and economical in operation and capable of moving under its own power over very difficult grades and soil conditions.

Following is a list of attachments available for use with tractors and photographs of some of them are shown:

1. Air compressors
2. Backfillers
3. Booms
4. Brooms
5. Bulldozers
6. Ditchers
7. Hoists
8. Graders
9. Loaders
10. Mowers
11. Post hole diggers
12. Pumps
13. Rock crushers
14. Saws
15. Scrapers—dragline
16. Scrapers—rotary
17. Scrapers—wheel
18. Snow plows
19. Stump pullers
20. Trailers
21. Wagons
22. Welding generators
23. Winches

In order to determine the extent to which the railroads are using this equipment and the purpose for which it is being used, a questionnaire was sent to 49 railroads that the Committee understood used track type tractors in some department. Thirty replies were received which indicate a widespread application on the roads using them and satisfaction with their performance. Several roads not owning tractors reported having rented them for special work or being familiar with their performance on contract work.

Classes of Work for Which Adapted

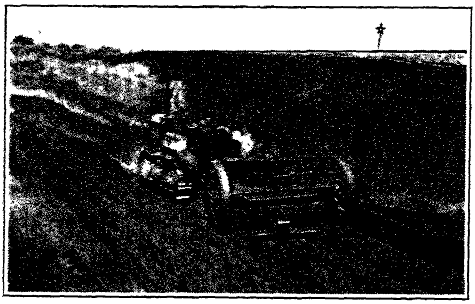
A study of the operation of these machines indicates that they have been used on the following classes of work:

Bank widening
Cleaning under bridges
Cleaning out culverts
Cleaning track ditches
Ditching around culverts
Ditching for surface drainage
Excavating for tracks
Excavating for buildings, bridges and grade separations
Plowing fire guards
Laying rail
Leveling the right-of-way
Leveling yards, cinder dumps and trash piles
Running tamping machines
Mowing weeds
Loading, unloading and hauling miscellaneous material
Removing snow around warehouses, crossings, tracks, platforms, driveways
Moving tracks
Removing tracks
Switching cars
Spray painting and other jobs requiring compressed air
Stripping gravel pits
Pumping water
Operating elevators for hoisting building material
Pulling stumps, clearing right-of-way
Cleaning out and digging new reservoirs with dragline
Moving buildings
Tearing down buildings
Clearing derailments
Welding rail ends, frogs and switch points
Stringing telephone and signal wires and cables, both overhead and underground

Examples of Specific Uses

Some specific examples of the performance of tractors with various auxiliary equipment are given below, with cost data and photographs taken on the job.

To permit of more accurate comparison with other methods, if desired, costs other than purely operating charges have been included. These costs are based on the following data for the tractors: insurance, 2 per cent of annual investment; taxes, 1 per cent of annual investment; supervision, 1 per cent of annual investment; depreciation period, 5 years or 8500 hours; interest rate, 6 per cent. The annual investment is determined by deducting 20 per cent of the first cost every year for five years, which will give the same result as the formula N plus 1 over $2N$, in which N is the number of years. The flat charges for the attachments are figured similarly, except the depreciation period varies with the different equipment. The cost of repairs is based on the study of several hundred machines operating on miscellaneous construction work and covers the cost of the parts and all expense of installation, including telegrams, etc. This gives a somewhat higher figure than is shown in the schedule of the Associated General Contractors.



BANK WIDENING BY SIDE BORROW

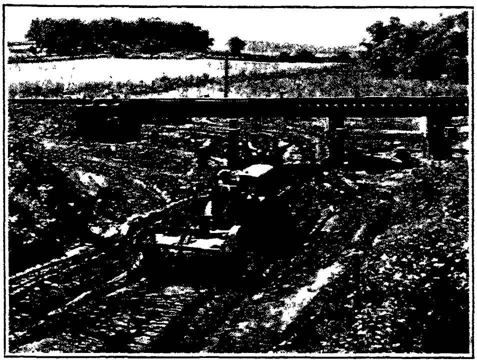
Equipment 25 H.P. Track Type Tractor and Hydraulic Roll-Over Scraper.

Conditions Height of fill average 9 ft. Bank widened 8 ft. on each side. Sandy soil. Single track main line. The shoulders had weathered down until ballast was spilling over bank.

Operation Work carried on by side borrow and building up from the bottom.

Costs

Tractor		
Gas 2.6 gal. @ .10	.26	
Oil and Grease	.07	
Operator	.76	
Total Operating Cost per hour		$1.090
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Scraper		
Insurance, Taxes, Supervision	.010	
Depreciation	.126	
Repairs	.063	
Supplies (cutting edges, hose)	.029	
Total Flat Charge per hour		.228
Total Cost per hour Tractor and Grader		$1.863
Average yardage moved per hour—20		
Operating Cost per cubic yard		$ .055
Total Cost per cubic yard		$ .093



EXCAVATING UNDER AND AROUND BRIDGE

EQUIPMENT A 25 H.P. Track Type Tractor and a Roll-Over Scraper.

CONDITIONS Footing uneven and wet. Material—sticky, black dirt.

OPERATION Earth was removed from underneath pile trestle bridge. Also waterway cleaned for a distance of 100 feet downstream. Material removed was placed alongside track in the form of bank widening.

COSTS

Tractor		
Gas 3 gal. @ .10	.30	
Oil and Grease	.07	
Operator	.76	
One Laborer	.35	
Total Operating Cost per hour		$1.480
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		$ .545
Scraper		
Insurance, Taxes, Supervision	.010	
Depreciation	.126	
Repairs	.063	
Supplies (cutting edges)	.029	
Total Flat Charge per hour		$ .228
Total Cost per hour Tractor and Scraper		$2.253
Average yardage moved per hour		17 cu. yards
Total Cost per cubic yard		$ .132

CLEARING OUT WATERWAY UNDER BRIDGE

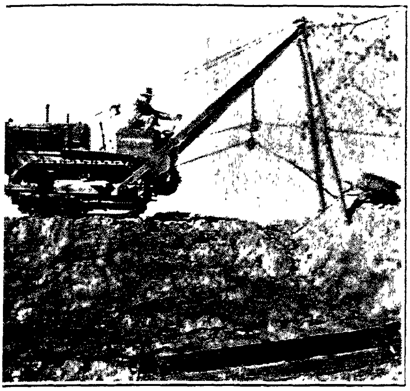
EQUIPMENT A 15 H.P. Track Type Tractor equipped with a double drum hoist, a drag scraper, a hand operated bulldozer, cables, pulleys, clamps, and an "A" frame.

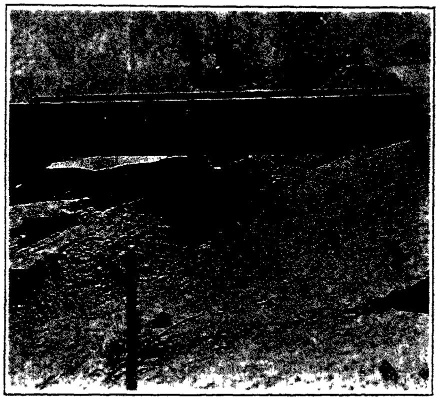
CONDITIONS Material moved was an accumulation of rocks, sand and clay which was removed from under the bridge and spread alongside the track.

OPERATION Material removed with dragline, spread with bulldozer.

COSTS

Tractor		
Gas 2.0 gal. @ .15	.30	
Oil and Grease	.05	
Operator	.75	
Foreman	.50	
2 Laborers	.64	
Total Operating Cost per hour		$2.240
Depreciation, Repairs, Insurance, Taxes		.427
Hoist		
Depreciation, Repairs, Insurance, Taxes		.133
Scraper		
Depreciation, Supplies, Insurance, Taxes		.058
Cables		
Depreciation per hour		.340
"A" Frame		
Depreciation per hour		.060
Bulldozer		
Depreciation, Repairs, Insurance, Taxes		.069
Total Cost of unit per hour		$3.327
Total job of 250 cubic yards required 72 hours		$239.54
Cost per cubic yard		$ 3.39





CLEANING OUT WATERWAY UNDER BRIDGE

EQUIPMENT A 25 H.P. Track Type Tractor equipped with a Double Drum Hoist, an "A" Frame, a ½ cubic yard Drag Scraper, Cables, Pulleys, Clamps.

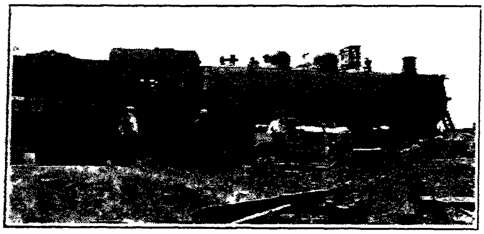
CONDITIONS The streambed under a plate girder bridge was filled to within 15 inches of the bottom of the girder.

OPERATION The tractor was "set up" on the downstream side of the bridge and at one side of the stream channel. The tail block was attached to a cable which was stretched across the stream on the other side of the bridge. By moving tail block along cable dirt could be removed from all parts of streambed under bridge.

COSTS

Tractor	
Gas, Oil, Grease, Operator, one helper, per hour	$1.382
Depreciation, repairs, insurance, taxes, supervision	.545
Hoist	
Depreciation, repairs, insurance, taxes, supervision	.123
Scraper	
Depreciation, repairs, supplies	.055
"A" Frame and cables	
Depreciation	.123
Total Cost per hour of entire unit	$2.228
Total Cost per cubic yard removed	$ .318

Time to complete job of 245 cubic yards—35 hours



LEVELING RIGHT-OF-WAY

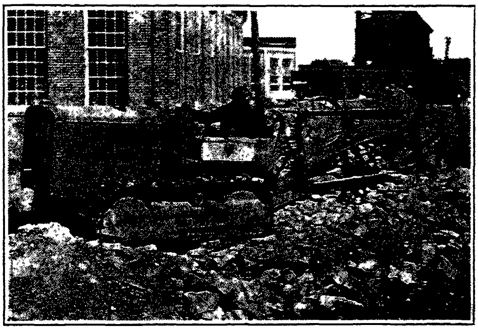
EQUIPMENT A 25 H.P. Track Type Tractor equipped with a Backfiller.

CONDITIONS A dike of sandy soil and old ties had been built to prevent drifting of sand.

OPERATION Required to level this dike by pushing the material away from the track.

COSTS

Tractor		
Gasoline 2.6 gal. @ .12	.312	
Oil and Grease	.105	
Operator	.515	
Total Operating Cost per hour		$ .932
Depreciation	.235	
Insurance, Taxes, Supervision	.028	
Repairs	.282	
Total Flat Charge per hour		.545
Backfiller		
Depreciation	.068	
Repairs	.034	
Insurance, Taxes, Supervision	.005	
Total Flat Charge per hour		.107
Total Cost per hour		$1.584
Labor		
2 Men @ .38 per hour	.760	
1 Flagman @ .38 per hour, half-time	.190	
Total Labor Charge		$ .950
Total Tractor, Backfiller, Labor per hour		$ 2.534
Cost per 8-hour day		$20.27
Total Cost per cubic yard moved		$ .126



CLEAN UP—400 CUBIC YARDS OF BRICK AND TRASH

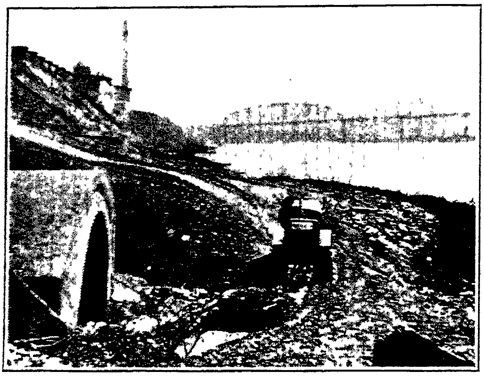
Equipment 25 H.P. Track Type Tractor and Roll-Over Scraper.

Conditions Clean up bricks removed on account of construction of addition to roundhouse. Haul—Round trip 1150 feet.

Operation Load in low; haul, dump and return in high. Round trip time 4 minutes.

Costs

Tractor		
Gas 2.7 gal. @ .10	.27	
Oil and Grease	.07	
Operator	.76	
Total Operating Cost per hour		$1.100
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Scraper		
Insurance, Taxes, Supervision	.010	
Depreciation	.126	
Repairs	.063	
Supplies	.029	
Total Flat Charge per hour		.228
Total Cost per hour Tractor, Scraper, Operator		$1.873
Total Work done—400 cubic yards		
Average per hour—13.3 cubic yards		
Total Cost for 400 cubic yards		$56.22
Total Cost per cubic yard		$ .14



CLEANING OUT A CULVERT

EQUIPMENT A 15 H.P. Track Type Tractor and an Ox Shovel—capacity ½ cubic yard.

CONDITIONS The culvert is 432 feet long, 7½ feet high and the accumulation of gravel was about 2 feet deep.

OPERATION The scoop was loaded by two men. Haul—375 feet. Total time—22 days of 8 hours each. Actual working time—6½ hours per day.

COSTS

Time—22 days @ 8 hours—176 hours

Rental on tractor and slip	$150.00
Gasoline for tractor	23.00
Oil and Grease	2.00
Labor	450.00
Total	$625.00

Total yardage—616 cubic yards

Total Cost per cubic yard	$ 1.01

CLEANING OUT TWO CULVERTS

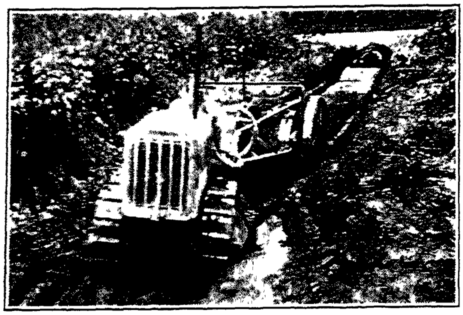
Equipment A 15 H.P. Track Type Tractor, a double drum hoist, a ½ cubic yard drag scraper, cables, pulleys and an "A" Frame.

Conditions Two culverts 5′10″ x 5′6″ x 595′ long were clogged with sand and gravel to a depth of about four feet.

Operation The dirt was removed with one "set-up" of the tractor for each culvert. A clamshell was used to load and haul away the material.
Two men were used; one operator and one helper.

Costs

Labor and Material setting up "A" Frame	$ 74.90
Operator and Helper	173.96
Gas and Oil for tractor	25.79
Clamshell expense loading and unloading waste material	51.91
Work train expense handling clamshell	107.45
Total cost	$434.10
Total yardage—444 cubic yards	
Cost per cubic yard	$ .98



CLEANING CULVERT DITCHES

EQUIPMENT — A 25 H.P. Track Type Tractor and a Roll-Over Scraper.

CONDITIONS — Cleaning out a ditch downstream from a 30 inch culvert. Earth sticky and wet.

OPERATION — Backed up culvert, loaded, pulling away—total 60 cubic yards—total time 3 hours.

COSTS

Tractor		
Gas 2.5 gal. @ .10	.25	
Oil and Grease	.07	
Operator	.76	
Total Operating Cost per hour		$1.080
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Scraper		
Insurance, Taxes, Supervision	.010	
Depreciation	.126	
Repairs	.063	
Supplies (cutting edges, hose)	.029	
Total Flat Charge per hour		.228
Total Cost per hour, Tractor, Scraper, Operator		$1.853
Average yardage per hour—20 cubic yards		
Total job—60 cubic yards. Time—3 hours		
Cost per cubic yard		$ .092
Cost of job—60 cubic yards		$5.520

SURFACE DITCHING

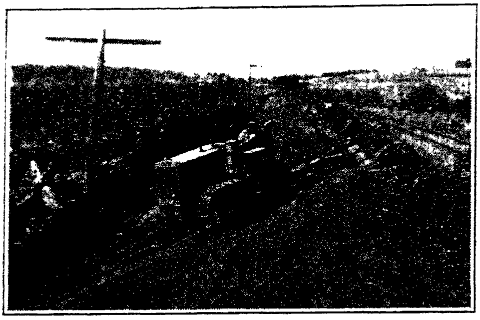
EQUIPMENT A 25 H.P. Track Type Tractor and a Grader.

CONDITIONS Ditch 900 feet long, 2½ feet deep and 8 feet wide to be built along the top of a cut section. Width of working area varied between 20 and 30 feet. Further obstructed by a line of telegraph poles.

OPERATION Straight ditching. Moved dirt from ditch and cast it up in the form of a dike. Two men employed.

COSTS

Tractor		
Gas 2.1 gal. @ .10	.21	
Oil and Grease	.07	
Operator	.76	
Total Operating Cost per hour		$ 1.040
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Grader		
Grease	.015	
Supplies (cutting edges)	.054	
Operator per hour	.350	
Total Operating Cost per hour		.419
Insurance, Taxes, Supervision	.016	
Depreciation	.133	
Repairs	.053	
Total Flat Charges per hour		.202
Total Cost per hour Tractor, Grader and Operators		$ 2.206
Average yardage moved per hour—40 cubic yards		
Total Cost per cubic yard		.055
Total Cost for job—480 cubic yards		$26.40



SURFACE DITCHING

EQUIPMENT A 25 H.P. Track Type Tractor, a Grader and a Roll-Over Scraper—capacity 1 cubic yard.

CONDITIONS Required to construct a surface ditch 1,000 feet long, 10 feet wide and 2½ feet deep and to place the dirt in the form of a dike on the downstream side of the ditch.

OPERATION Two men required to do the job. Washouts filled by back dumping with Scraper. Final shaping done with Grader.

COSTS

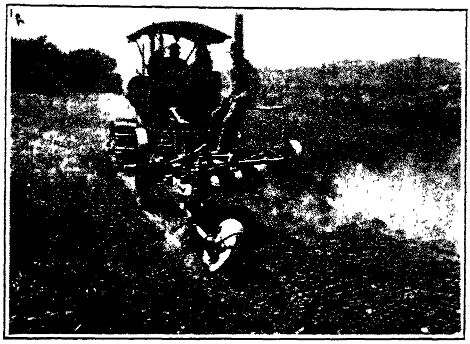
Tractor		
Gas 2.1 gal. @ .10	.210	
Oil and Grease	.070	
Operator	.760	
Total Operating Cost per hour		$ 1.040
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Grader		
Lubricants	.015	
Operator	.350	
Total Operating Cost per hour		.365
Insurance, Taxes, Supervision	.014	
Depreciation	.133	
Repairs	.053	
Supplies (cutting edges)	.054	
Total Flat Charges per hour		.254
Scraper		
Insurance, Taxes, Supervision	.010	
Depreciation	.126	
Repairs	.063	
Supplies (cutting edges)	.029	
Total Flat Charges per hour		.228
Total Cost per hour Tractor, Grader, and Scraper		$ 2.432
Total Time for job—51 hours		
Total Yardage—471 cubic yards		
Total Cost for job		$124.03
Total Cost per cubic yard		$ .26

CLEANING TRACK DITCHES

EQUIPMENT	A 25 H.P. Track Type Tractor and Roll-Over Scraper.		
CONDITIONS	Soil sandy.		
OPERATION	Clean track ditch 1500 feet long. Round trip distance 3400 feet. Time for round trip—10 minutes. 2 cubic yards per round trip. Load in low—haul in high.		
COSTS	Tractor		
	Gas 2.7 gal. @ .10	.27	
	Oil and Grease	.07	
	Operator	.76	
	Total Operating Cost per hour		$1.100
	Insurance, Taxes, Supervision	.028	
	Depreciation	.235	
	Repairs	.282	
	Total Flat Charge per hour		.545
	Scraper		
	Insurance, Taxes, Supervision	.010	
	Depreciation	.126	
	Repairs	.063	
	Supplies (cutting edges, hose)	.029	
	Total Flat Charge per hour		.228
	Total Cost per hour Tractor and Scraper		$1.873
	Average yardage moved per hour—11		
	Total Cost per cubic yard		$ .17

EXCAVATING FOR STORAGE TRACKS

EQUIPMENT	A 25 H.P. Track Type Tractor and a Roll-Over Scraper.		
CONDITIONS	Depth of cut 2 feet 8 inches. Material—cinders and hard packed clay.		
OPERATION	Dirt removed from two cuts—one 70 feet long, one 90 feet long, width at bottom 10 feet, haul 200 feet, time per trip 2 minutes. No scarifying necessary.		
COSTS	Tractor		
	Gas 2.5 gal. @ .10	.25	
	Oil and Grease	.07	
	Operator	.76	
	Total Operating Cost per hour		$1.080
	Insurance, Taxes, Supervision	.028	
	Depreciation	.235	
	Repairs	.282	
	Total Flat Charge per hour		.545
	Scraper		
	Insurance, Taxes, Supervision	.010	
	Depreciation	.126	
	Repairs	.063	
	Supplies (cutting edges, hose)	.029	
	Total Flat Charge per hour		.228
	Total Cost per hour, Tractor, Scraper, Operator		$1.853
	Average yardage moved per hour—23		
	Total Cost per cubic yard		$ .08
	Total number cubic yards—244		



PLOWING FIRE GUARD

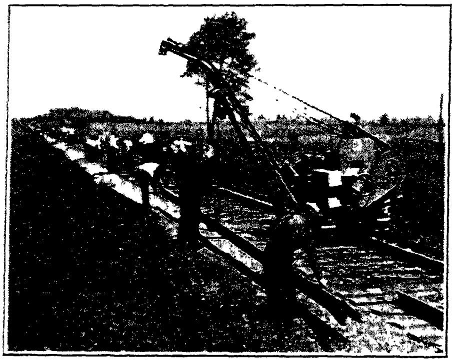
EQUIPMENT — A 30 H.P. Wide Gage Track Type Tractor and a 5-bottom 14-inch Sod Plow.

CONDITIONS — Plowing sod, swamp, loose soil; crossing drainage ditches and other obstructions.

OPERATION — Plowing one trip 50 to 150 feet from center line.

COSTS

Tractor		
Gas 2.8 gal. @ .12	.336	
Oil and Grease	.095	
Operator	.900	
1 Laborer	.700	
Total Operating Cost per hour		$2.031
Taxes, Insurance, Supervision	.038	
Depreciation	.270	
Repairs	.297	
Total Flat Charge per hour		$ .605
Plow		
Taxes, Insurance, Supervision	.004	
Depreciation	.036	
Repairs	.018	
Supplies (plow points)	.010	
Total Flat Charge per hour		$ .068
Total Cost per hour Tractor, Plow Driver, and Labor		$2.704
Average amount of fire guard built per hour—2 miles		
Total Cost per mile		$1.352



LAYING 110-LB. RAIL—39-FT. LENGTHS

EQUIPMENT A 25 H.P. Track Type Tractor equipped with a Side Boom Winch.

CONDITIONS Single track main line carrying from eight to twelve trains during the working day. Numerous switches and street crossings.

OPERATION The Tractor placed rails, frogs, switch points, etc. Removed rail from street crossings in 3 rail length sections. Placed 3 welded rail lengths at one time in street crossings. Unloaded frogs and switches from flat cars.

COSTS

Tractor		
Gas 1.45 gal. @ .10	.145	
Oil and Grease	.070	
Operator	.760	
Total Operating Cost per hour		$ .975
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Side Boom		
Insurance, Taxes, Supervision	.025	
Depreciation	.314	
Repairs, Cables and Supplies	.160	
Total Flat Charge per hour		$ .499
Total Cost per hour Tractor, Side Boom and Operator		$2.019
Average rails laid per hour—23.8		
Maximum rails laid per hour—60.0		
Cost per 39-ft. rail based on average		$ .0847
Cost per 39-ft. rail based on maximum		$ .0336

SPREADING AND LEVELING CINDERS

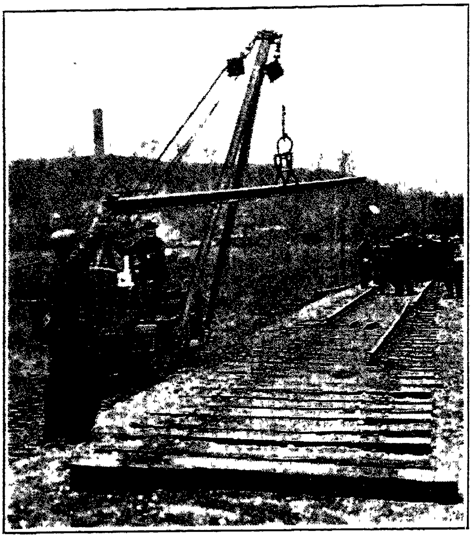
EQUIPMENT A 25 H.P. Track Type Tractor, a Grader, and a Roll-Over Scraper.

CONDITIONS Cinders unloaded in piles alongside track by clamshell.

OPERATION Cinders were hauled to low places with scraper and entire yard was leveled with grader.

COSTS

Tractor		
Gas 2.7 gal. @ .10	.27	
Oil and Grease	.07	
Operator	.76	
Total Operating Cost per hour		$ 1.100
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Grader		
Grease	.015	
Operator	.375	
Total Operating Cost per hour		.390
Insurance, Taxes, Supervision	.014	
Depreciation	.033	
Repairs	.053	
Supplies (cutting edges)	.054	
Total Flat Charge per hour		.254
Scraper		
Insurance, Taxes, Supervision	.010	
Depreciation	.126	
Repairs	.063	
Supplies (cutting edges)	.029	
Total Flat Charge per hour		.228
Total Cost per hour Tractor, Grader, Scraper		2.517
Total Cost for job—15 hours		$37.75



REMOVING TRACK

EQUIPMENT A 25 H.P. Track Type Tractor and a Side Boom.

CONDITIONS Required to load all material from 5887 feet of track on flat cars. This included loading 2505 ties, 3 toilets, 3 coal boxes, 2 switches, and one flag shanty in addition to the rail.

OPERATION The entire job done with one foreman and seven laborers in approximately twelve 8-hour working days.

COSTS

Tractor		
Gas 2.6 gal. @ .10	.26	
Oil and Grease	.07	
Operator	.50	
Total Operating Cost per hour		$ .830
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Side Boom		
Insurance, Taxes, Supervision	.025	
Depreciation	.314	
Repairs, Cables and Supplies	.160	
Total Flat Charge per hour		.499
Total hourly cost of Tractor and Side Boom		1.874
Total Machinery Cost 76.5 hours @ $1.874		143.36
Section Foreman—91 hours @ $.625		56.88
Labor—636 hours @ $.40		254.40
Welder—6 hours @ $.60		3.60
Total Cost		$458.24
Cost per track foot		$ .078
Cost per track mile		$411.84

TAMPING TIES WITH AIR TOOLS

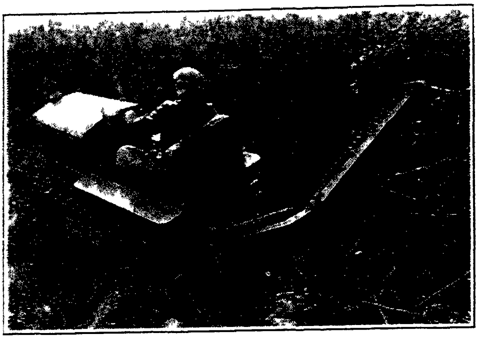
EQUIPMENT A 25 H.P. Track Type Tractor equipped with a Compressor. Operating four tampers.

CONDITIONS New pit run gravel ballast. Track raised an average of 3 inches. 110-lb. rail.

OPERATION A crew of 23 men raised all track, tamped ties, tightened bolts and spikes, and dressed shoulders.

COSTS

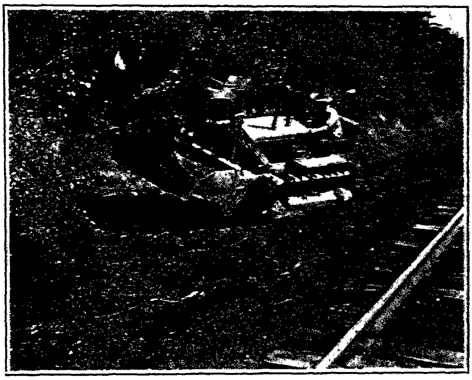
Tractor		
Gas 2.8 gal. @ .10	.28	
Oil and Grease	.07	
Operator	.76	
Total Operating Cost per hour		$1.110
Insurance, Taxes, Supervision	.028	
Depreciation	.235	
Repairs	.282	
Total Flat Charge per hour		.545
Compressor		
Insurance, Taxes, Supervision	.017	
Depreciation	.176	
Repairs	.088	
Supplies (hose, etc.)	.044	
Total Flat Charge per hour		.325
Tampers		
Insurance, Taxes, Supervision	.006	
Depreciation	.029	
Repairs	.014	
Total Flat Charge per hour		.049
Total Cost per hour Tractor, Compressor, Tampers		$2.029
Average number of ties tamped per hour (4 faces)—167		
Cost per tie tamped (4 faces)		$ .012



MOWING WEEDS

EQUIPMENT	A 10 H.P. Track Type Tractor equipped with a 6-foot mower.
CONDITIONS	Right-of-way width 100 feet. Topography irregular. Weeds about 4 feet high and very dry.
OPERATION	Cut close to fence, and on side slopes.

COSTS			
	Tractor		
	Gas 1.4 gal. @ .10	.140	
	Oil and Grease	.050	
	Operator per hour	.500	
	Total Operating Cost per hour		$ .690
	Insurance, Taxes, Supervision	.016	
	Depreciation	.135	
	Repairs	.175	
	Total Flat Charge per hour		.326
	Mower		
	Insurance, Taxes, Supervision	.004	
	Depreciation	.049	
	Repairs	.025	
	Supplies (sickle blades)	.020	
	Total Flat Charge per hour		.098
	Total Cost per hour Tractor, Mower, Operator		1.114
	Cost per track mile of right-of-way		$11.44



BUILDING DRAINAGE DITCHES

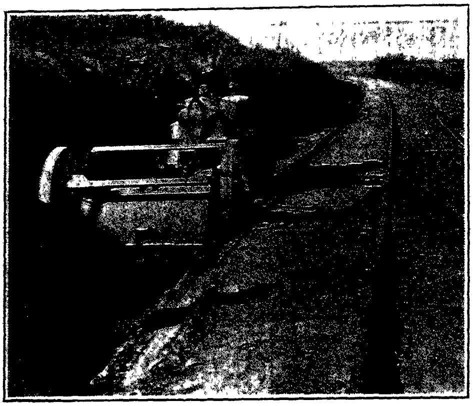
EQUIPMENT A 25 H.P. Track Type Tractor and small grader.

CONDITIONS Old ditches three feet from ends of ties in flat country, caused water standing in ditch to saturate subgrade.

OPERATION New ditch was cut 9 feet from end of ties with grader and old ditch filled and leveled with surplus material.

COSTS

Tractor	
Gas, oil, grease and operator, per hour	$ .760
Depreciation, repairs, insurance, taxes, supervision	.468
Grader	
Grease and operator per hour	.610
Depreciation, repairs, insurance, taxes, supervision, supplies per hour	.146
Total cost per hour of entire unit	$ 1.984
Total cost per mile of ditch complete	$79.20



CLEANING TRACK DITCHES WITH DITCHER

EQUIPMENT	A 25 H.P. Track Type Tractor equipped with front end ditcher.
CONDITIONS	Length of cut, 500 feet. Material varied from hard clay to mud.
OPERATION	Work was carried on by digging bank back, beginning at one end and hauling material to end of cut, dumping over edge of fill.

COSTS

Tractor		
Gas, oil, grease, operator per hour	$ .870	
Insurance, taxes, supervision, depreciation and repairs per hour	.522	
Ditcher		
Supplies, cutting edges, cables, etc. per hour	.050	
Insurance, taxes, supervision	.249	
Total Cost entire unit per hour		$1.691
Average yards moved per hour—12 cu. yds.		
Operating cost per cubic yard		$ .072
Total Cost per cubic yard		$ .141

Summary

1. The track type tractor works with a minimum interference to rail traffic.
2. Work can be done at points not served by tracks.
3. The tractor can be loaded on a flat car by its own power.
4. The smaller sizes can be transported on a heavy duty push car or moved along the right-of-way under its own power
5. The tractor is adaptable for use with small gangs.
6. It can be used independently or as a part of larger operations, such as leveling ridges left by ditcher spreaders, etc.
7. It is suitable for work during all seasons of the year.
8. It does not require a skilled operator but can be driven by labor of ordinary intelligence and experience.
9. It can operate over ground where teams or wheeled vehicles would bog.

Conclusions

Supplemented with suitable auxiliary equipment, track type tractors are adaptable to the economical and efficient performance of many classes of maintenance of way work and are sufficiently versatile to permit of all-year use.

The Committee recommends that the subject be continued.

Appendix D

(9) ORGANIZATION FOR USE AND MAINTENANCE OF TIE TAMPING MACHINES—AIR AND ELECTRIC

L. B. Holt, Chairman, Sub-Committee; M. D. Bowen, Robt. Faries, R. J. Gammie, Paul Hamilton, F. S. Hewes, H. I. Hoag, R. H. Kugler, C. H. Morse, E. H. Ness, Harry Slabotsky, F. M. Thomson, J. B. Trenholm.

After reviewing information as to practices of railroads using tie tamping machines your Committee has reached the conclusion that, generally speaking, there are few fundamental differences in the methods employed.

It is thought advisable to make a concise statement of what appear to be the best practical standards to follow and then each railroad can apply them with such modifications as their individual requirements dictate.

Tie tamping machinery has been in service since 1913, in which year the first successful pneumatic unit, consisting of a single cylinder compressor and two tampers, was developed. Progressive improvements have been made until now we have as standard 2, 4, 8, 12 and 16 tool machines.

The electric tamper dates from 1918 when the "vibrator" type was developed. Ten years later the magnetically operated tool was introduced. In 1930 the motor driven "hammer blow" tamper was put on the market and in 1931 an "air-electric" tamper was put out for field test. It is now possible to obtain electric tamping outfits consisting of 2, 4, 6, 8, 12 and 16 tool machines.

Efficient and economical results with tie tamping machinery can only be accomplished when the mechanism is in good working order and manned by reliable men under the direction of a competent foreman.

Following is a statement of what appears the best balanced gang organizations for good, economical surfacing work, with the most commonly used units, namely, the four, eight and twelve tool outfits of either pneumatic or electric type. These organizations

are designed for surfacing work only, excluding labor for spacing and renewing of ties, as such work is outside the scope of this subject. When tie spacing and renewals are involved such additional men as may be required can be added to the organizations shown.

ORGANIZATION OF GANG FOR OPERATING FOUR TOOL OUTFITS

1 foreman
1 machine operator and handyman
4 men on tampers
1 man on jacks; also change off on tampers
2 men handling ballast and hose or electric cables; also change off on tampers
—
9 men

ORGANIZATION OF GANG FOR OPERATING EIGHT TOOL OUTFITS

1 foreman
1 machine operator and handyman
8 men on tampers
2 men on jacks; also change off on tampers
2 men handling ballast and hose or electric cables; also change off on tampers
1 man dressing off ballast
1 water boy
—
16 men

ORGANIZATION OF GANG FOR OPERATING TWELVE TOOL OUTFITS

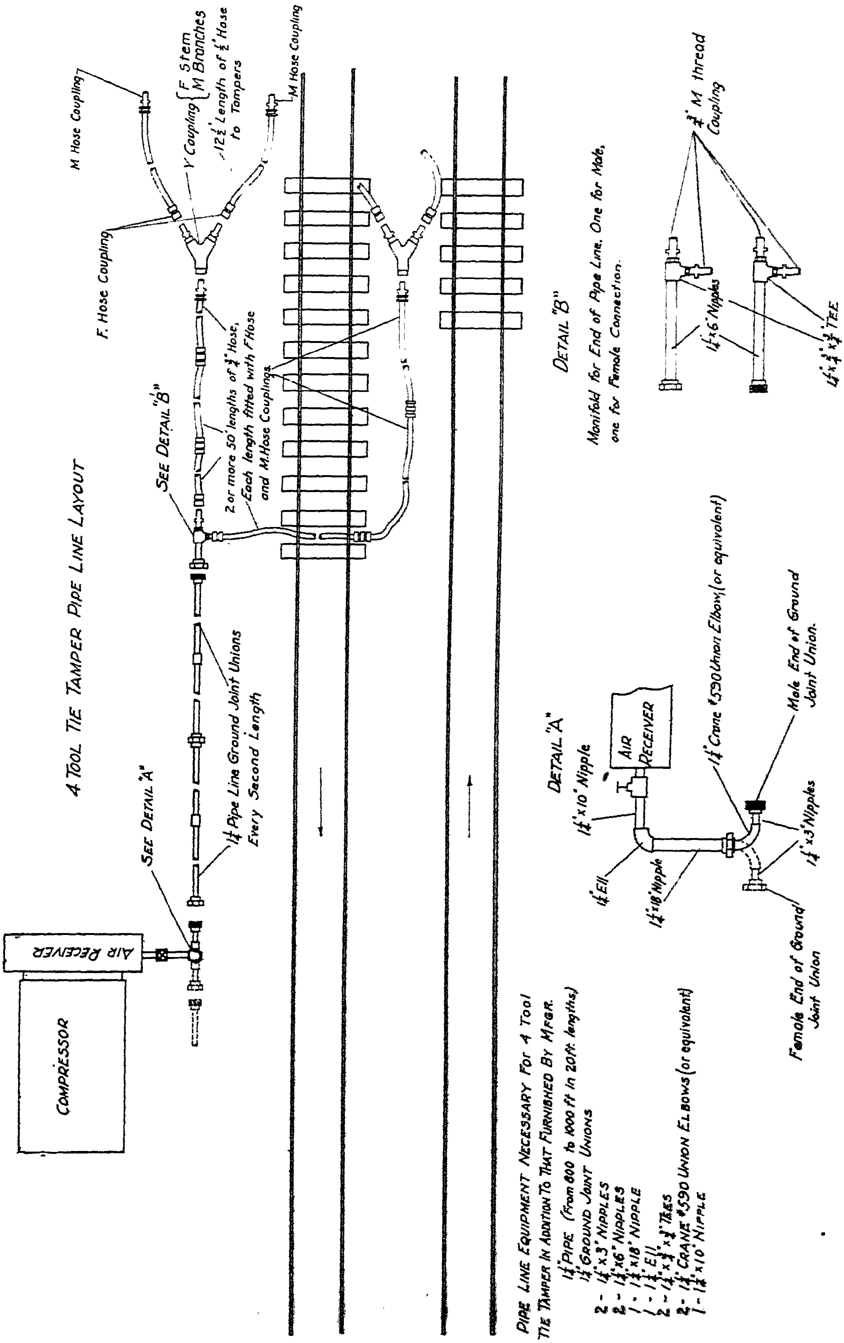
1 foreman
1 assistant foreman
1 machine operator and handyman
12 men on tampers
4 men on jacks; also change off on tampers
2 men cleaning out ballast ahead of tampers
2 men forking ballast; also change off on tampers and handle hose or electric cable
1 water boy
—
24 men

Ordinary maintenance of tie tamping machinery during the operating season, such as greasing, oiling, cleaning, renewing spark plugs, flushing radiators, oiling tampers, changing gaskets, etc., should be handled by the operator who should be selected because of his aptitude along mechanical lines.

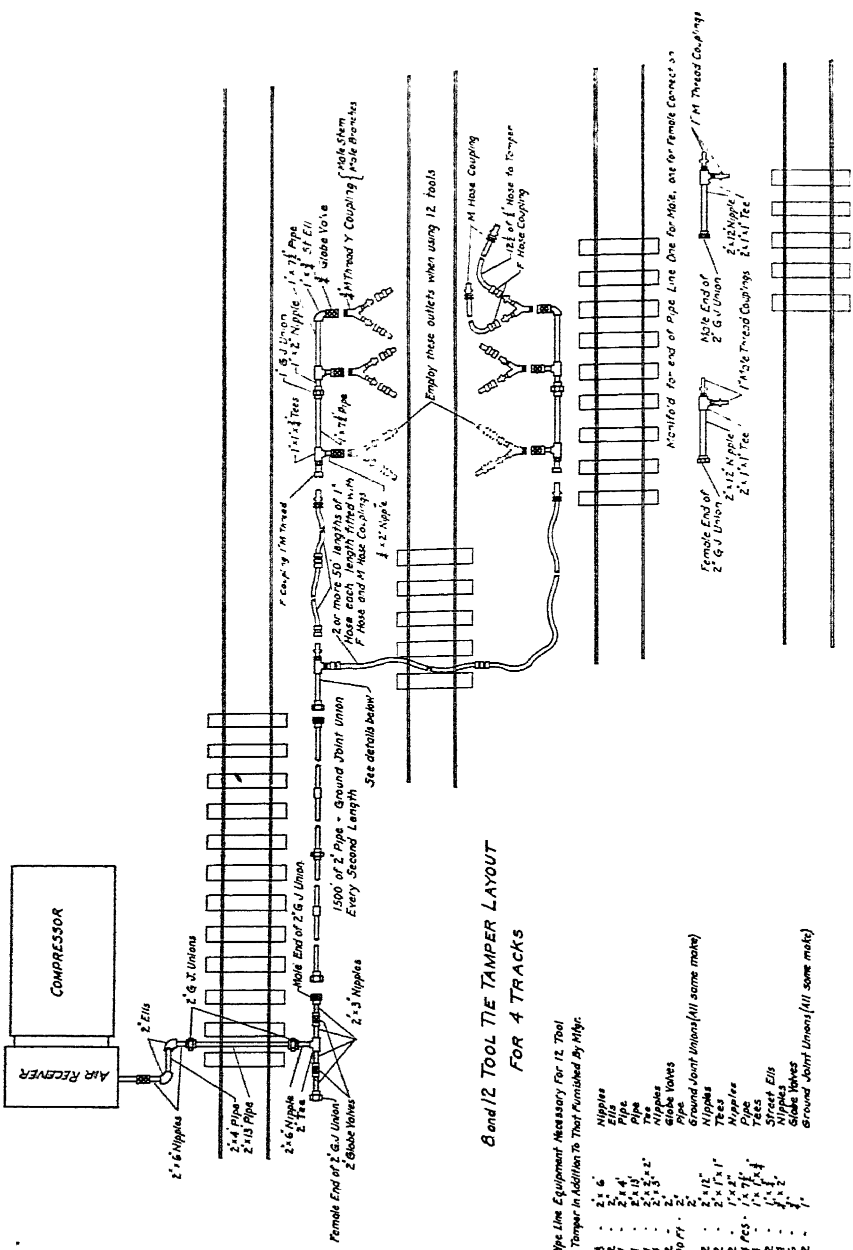
More complicated field repairs should be taken care of by the Division Mechanic who normally cares for gasoline engines, motor cars, etc., or the electrician whose duty it is to service electric tools. These men must make regular and systematic inspections of all tamping outfits under their jurisdiction and be responsible for the successful operation of same.

At the close of the operating season the complete tamping outfit, including tools, should be sent to the Division or Centralized Shop where it should be gone over thoroughly by competent mechanics who will replace or repair all defective parts, clean the equipment thoroughly inside and out and after painting, store same under suitable cover until needed in the spring.

During the winter overhauling of tamping outfits special attention should be given to the pneumatic tamping guns. This would include a thorough test to determine whether they are in efficient working condition or whether the pistons and cylinders are so worn that they are not giving profitable service. Guns in normal condition should use about 17 cu. ft. of air per minute at 90 pounds pressure and when the test indicates that the guns use 22 or more cu. ft. per minute they should either be replaced or the cylinders should be re-ground and over-size pistons applied so as to restore efficiency of the tool.



SUGGESTED PIPE ARRANGEMENT FOR FOUR TOOL PNEUMATIC OUTFITS.



SUGGESTED PIPE ARRANGEMENT FOR EIGHT AND TWELVE TOOL PNEUMATIC OUTFITS AS USED ON FOUR TRACKS. (With slight modifications, can also be used for two tracks)

(Details may be modified so as to employ other suitable pipe fittings)

The Division or Centralized Shop should be located adjacent to a sidetrack so that tamping equipment can be readily unloaded from and reloaded into cars. The shop should be equipped with necessary machine tools requisite for ordinary maintenance repair work and hoists, either hand operated or electrical, should be provided to facilitate the work.

If the compressing or generating units, as the case may be, require unusually heavy repairs or replacements it is usually best to return this equipment to the manufacturer who is better equipped to take care of any essential work and restore the outfit to its original state of efficiency.

Power cables for electric tampers are provided by the manufacturer to suit his type of tamping unit. Some manufacturers employ one and others two line cables, therefore, the cable arrangement is governed by the type of machine used and diagrams to illustrate a standard cable layout along the tracks is not feasible.

Appendix E

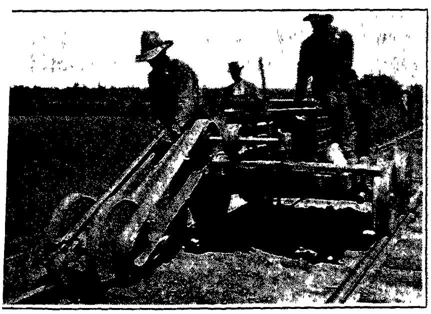
(12) TIE ADZING, SCORING AND BORING MACHINES

A. I. Gauthier, Chairman, Sub-Committee; J. J. Davis, Wm. Elmer, W. R. Gillam, R. C. Haynes, F. S. Hewes, F. W. Hillman, L. B. Holt, C. H. R. Howe, A. J. Neafie.

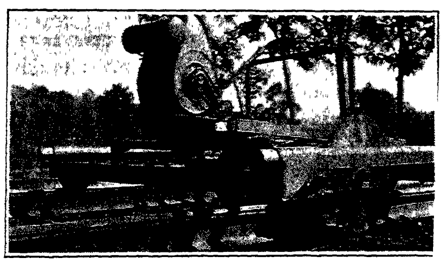
In developing the report the Committee has given attention to the adzing and boring of ties in the field and not at the treating plant, believing that information desired deals with portable machines and their use on the track.

Wood boring machines have been in use for a considerable length of time, whereas scoring and adzing machines have been developed to their present state in recent years.

Gasoline driven scoring machines which score the ties to required depth as a guide for hand adzing are designed to operate either two or four saws and make cuts across the ties on both sides of one or both rails to the proper depth, which is usually the seat of the rail or tie plate. The machine, once adjusted, does the scoring a uniform distance from top of head of rail, and in passing over new ties in which plates or rail are not



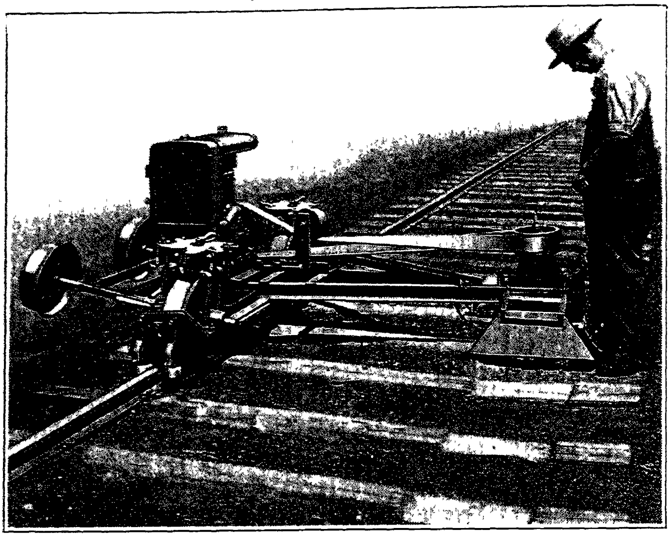
Tie Scorer.



Pennsylvania Tie Scorer.

embedded scores them a minimum amount, whereas old, rail cut or plate embedded ties are scored to the same depth in relation to top of rail head. The scoring machine also permits the adjustment of saws so that those on the inside of rail will score ties to a greater depth than those on the outside and with the hand adzing to the bottoms of scores; this provides a bevelled surface on ties and the consequent canting of rail without the use of canted plates.

The tie adzing machine which performs the entire operation of adzing in connection with rail laying was developed about four years ago. Adzing is done by a series of bits securely fastened to a cutter head on a vertical shaft, belt driven from a gasoline engine located over two main wheels, which ride rail in tandem fashion and which are kept in



Tie Adzer.

position by sets of guides. This cutter head, operating a uniform distance from the working rail, is provided with a gage plate on the under side and flush with the cutter bits which serves as a guide and permits the adzing of the ties to rail or tie plate seat. If, however, it is desired to remove wood below rail or tie plate seat, this can be accomplished by starting the cutting on the edge of tie and moving the cutter head across it. Cutter head can be set to adze perfectly level or on any desired cant.

Boring machines are either of the pneumatic or electric type with power obtained from gasoline engine driven compressor or generator. Standard power drills, both electrical and pneumatic, are adaptable to this work and commonly used.

The Committee has endeavored to ascertain to what extent these portable machines are used and while contact has not been made with all railroads, the questionnaire prepared has been answered by a representative number of roads.

Where hand adzing is done, scoring machines have not been generally used. Neither are scoring machines used in conjunction with adzing machines. In using the scoring machine either two or four saws may be used, depending on the make of the machine. It is the opinion of those using the scoring machine that it is essential to a good job where hand adzing is done and almost indispensable to provide uniform bearing for rail when rail laying is done in the winter time, thus eliminating large amount of shimming. Before scoring machine is used all ties should be tamped snugly to base of rail when possible.

In using adzing machine maximum amount of adzing can be controlled by adzing until gage plate comes in contact with old rail or tie plate seat, but this will not generally be the proper depth for laying rail on uniformly thick tie plates on account of the fact that old plates may not be of same thickness and all ties may not have been fur-

nished with plates. However, it is not the practice to do all of the adzing on each individual tie by one machine. Machines are employed in batteries of from two to four, principally three, the first two machines making the rough cuts and the last machine making the finish cut. Machines are not held stationary over a tie but are worked progressively along the track, each machine beginning the work of adzing at edge of tie and going across the upper face of it. This greatly facilitates the work but leaves the proper amount of adzing to the judgment of the operator.

Before adzing machines are used it is necessary to lower the ballast in the cribs between the ties to prevent fouling cutter bits and immediately ahead of the machine it is customary to sweep the tops of ties clean of all dirt.

The majority of roads adze ties level.

In using adzing machine, operators are protected by wearing goggles and shin guards, although later machines are provided with guard around the cutter head which prevents chips and stones being thrown about.

It is the practice to apply wood preservative, generally creosote oil, to all surfaces of treated ties where adzing has been done either by hand or by machine. The Committee recommends the application of hot creosote oil.

It is the opinion, based on experiences of those roads employing adzing machines, and the belief of some who do hand adzing, that the use of adzing machines provides a very accurate seat for the rail which therefore requires less regageing. It also prevents bent tie plates and damaged rail.

Where tie plating is being done out of face, if rail is removed, good bearing for rail can be provided by using adzing machines similar to where rail is laid and with equally good results, but where rail is left in place, adzing machines cannot be used and adzing has to be done by hand. The use of scoring machines on this work will furnish accurate guide for hand adzing and provide good bearing for tie plates. This is especially true if the plating is done in the winter time.

Boring for rail spikes is done in almost all cases at treating plant before ties are treated. The exceptions are for ties used with light rail or ties of low grade. The small amount of boring done in the field is either done by hand or by machine operated pneumatically or electrically.

The practice of lagging tie plates does not seem to be general but where these and certain types of joint plates are lagged, it is the practice in almost all instances to bore holes for lag spikes or screws at treating plant before ties are treated.

The Committee endeavored to obtain information on the cost per track mile of hand adzing, tie scoring and machine adzing, but owing to the wide variation in cost figures furnished due to different methods of doing work and variable working conditions, do not believe they are of much value. Neither were cost figures on operation of boring machines available.

Conclusion

While it is possible to obtain good riding track by laying rail on ties adzed by hand, without the use of any machinery, and do the work in such a manner as to provide good bearing for the rail without bending of tie plates and consequent damage to rail, this is a costly method of doing the work. A much better job of adzing can be obtained by the use of the scoring machine in connection with hand adzing and a better and much less costly job can be obtained by employing adzing machines.

Uniform machine adzing can be obtained by use of scoring machine to go ahead of adzing machine to score a groove in each tie. Providing the adzing machine with a runner to take bearing in bottom of groove would control the amount of adzing and not leave it to the judgment of operator.

Appendix F

(13) THE USE OF DITCHING-SPREADERS

C. L. Fero, Chairman, Sub-Committee; W. R. Gillam, Paul Hamilton, G. W. Hunt, R. H. Kugler, R. A. Morrison, E. Pharand, H. Slabotsky, H. W. Stetson, Fred Zavatkay.

Introduction

In compiling this report the Committee has endeavored to ascertain to what extent Ditching-Spreaders are used on the railroads, the saving over hand labor and the various operations performed with this type of machine.

Ditching equipment falls into two classes, namely, "On-the-track" machines and "Off-the-track" machines. The Committee has not considered "Off-the-track" machines as this class of equipment does not come within the scope of the term "Ditching-Spreader."

The maintenance or cutting of new ditches along a railway roadbed is usually accomplished by three types of "On-the-track" machines. The first of these is the locomotive type which picks up the material by means of a bucket or shovel depositing it in cars or wasting it over banks wherever possible. It can readily be seen that this type does not come within the category of "Ditching-Spreaders." The second and third are the wing and box type respectively, which are covered in this report.

History and Development

The forerunners of the present ditching-spreaders were home-made units known as shoulder or ballast plows having comparatively short wings and are now practically obsolete.

These were followed by the first of the wing type spreaders having wooden wings, faced with steel and could only be used for spreading operations.

In the fall of 1918, the manufacturers of the wing type machine added a ditching feature consisting of a steel template wing with the bottom edge constructed to conform to the shape of the cross-section of the shoulder and ditch.

Various refinements have followed such as in 1920 air operated diagonal braces. In 1922 the composite machine (which eliminated two sets of wings, i. e., spreader and ditcher), and in 1924 air cylinders to raise and lower bank slopers, air motors to raise and lower the ditching section, and stop pin hydraulic cylinders to hold bank slopers in the different positions.

The heavy-duty telescopic wing type machine introduced in 1929 more nearly meets the requirements of an adequate Ditching-Spreader.

In 1931 the self-propelled box type machine was presented to the railroads. This type of machine is in the experimental stage and not in general use as yet.

Types and Age of Machines Reported

The Committee's survey of the machines owned by the various trunk line systems reveals the following information relative to types. Of those in use, 32 per cent are of the new telescopic wing type. Forty per cent are of the composite type and the remaining 28 per cent are of the earlier models.

There were no home-made or box type machines reported as being in use, although there are a few of the home-made ballast plows still being used for certain operations on a few railroads.

The age of the machines varied from 3 to 20 years.

System Equipment

Practically all the railroads reporting consider their Ditching-Spreaders as "system" equipment. A few lines allot units to certain divisions for snow service during the winter months.

Operations Performed

Reports received indicate the general use of wing type Ditching-Spreaders for the following operations:

a. Cleaning, ditching, and shaping of roadbed, shoulder and ditch
b. Bank sloping of cuts
c. Bank widening on fills
d. Dragging dirt out of cuts onto fills
e. Distribution, shaping and dressing of ballast
f. Spreading for second main or additional tracks and track elevation work
g. Removal of snow from main lines adjacent to yard tracks
h. Removal of snow and ice between and outside of rails with front plow, wings and ice cutting attachment
i. Plowing off stone ballast shoulder for cleaning
j. Leveling back old ballast shoulder below bottom of ties, previous to applying new gravel or rock ballast
k. Cutting down sub-grade from 18" to 20" below bottom of ties and about 8" from end of ties to get rid of bad material in sub-grade
l. Spreading cinder piles at the various engine houses or cinder dumps

Derailing

Seventy-six per cent of the lines indicated that they experienced little or no trouble from derailing of this type of equipment, when reasonable judgment was used in the depth of cut or amount of material moved.

In some cases, however, this trouble was encountered when dragging one wing only in a cut and was overcome by opening the wing on the opposite side and allowing it to drag slightly.

In another instance, derailing was overcome by placing additional weight on the body of the machine.

In a third instance, this difficulty was met with in spreading material deposited by air dump cars and was corrected by not allowing too much material to be dumped in one spot, i. e., by keeping the cars moving along slowly while dumping and by not attempting too deep a cut the first time over.

In some cases teeth are applied to wings to plow hard material.

Operators

In practically every instance the replies indicated that selected men were trained to operate these units.

The practice of one of the railroads, while it seems to be an exception to the tendency stated above, is well worth mentioning. When its ditching-spreaders are operated in conjunction with steam or gas ditchers, the ditcher operator alternates between the Ditcher-Spreader and ditcher. On the other hand, when the spreader is used independently the Section Foreman operates it.

Crew

In regard to the number of men making up the crew of a Ditching-Spreader, other than the operator, an analysis of the replies shows the following:

Forty-six per cent of the roads assign 1 man.
Thirty-one per cent provide no crew to assist the operator.

Eight per cent assign a foreman and three men.
Eight per cent assign 1 man for ditching and shaping operations and 4 to 6 men for general work.
The remaining seven per cent use the unit in work train service and the work train gang assist in its operation as needed.

Responsibility for Operation and Performance

Responsibility for the proper operation and performance of the unit and for the maintenance of proper ditch and shoulder section was placed upon Roadmasters by thirty-one per cent of the railroads. Nine per cent placed this responsibility on the work train foreman. The remaining sixty per cent reported equally on track supervisors, section foremen, operators of the units and foremen assigned to the units as being answerable for such performance.

Ditching-Spreaders Versus Other Methods

That the adaptability and economy of this machine in ditching operations is fully realized is forcibly illustrated by the fact that over one-half of the lines report that they now use this unit to perform eighty per cent or more of this kind of work which was formerly done by other methods.

Miles Per Day

Conditions under which the machine is operated such as traffic, character of material handled and nature of work done vary to such an extent that results accomplished are not comparable. Reports indicate a wide variation in miles per day, ranging from 3 miles as a minimum to 40 miles when working in light sand or loam.

Savings Through Use

The varied nature of the work done by this type of machine is such that no definite figures as to cost per yard or mile of ditch cleaned or made can be given. However, reports indicate that the use of the machine results in savings as high as 80 per cent under the cost of hand and team work and 60 per cent under the cost of ditching by dipper type of ditchers.

Cost Per Cubic Yard

It is obviously difficult to show definitely the cost of moving material without taking into consideration the nature of material handled and conditions under which the work is done. Costs range from 17 cents to 25 cents per cubic yard with Ditching-Spreaders while hand work ranges from 35 cents to $1.00, team work 25 cents to $1.00 and steam or gasoline ditcher 17 cents to 52 cents.

Days Worked Per Year

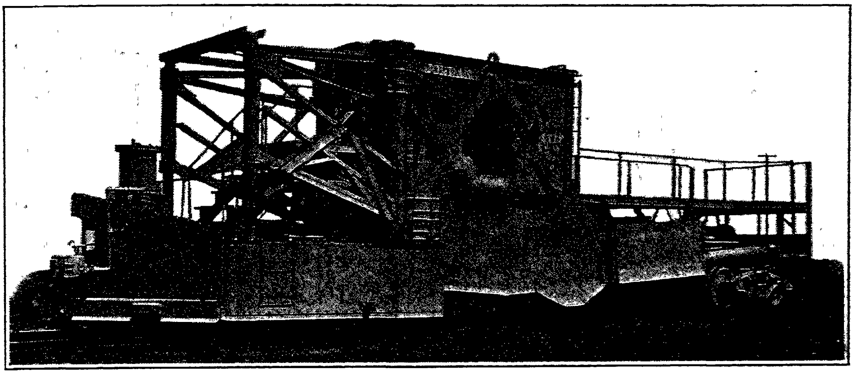
Compilation of answers to the question regarding the average number of days that the machines work per year follows:

Machines working less than 100 days per year	8 per cent
" " 100 to 150 " " "	25 per cent
" " 150 " 200 " " "	25 per cent
" " 200 " 250 " " "	25 per cent
" " 250 " 300 " " "	9 per cent
" " every working day	8 per cent

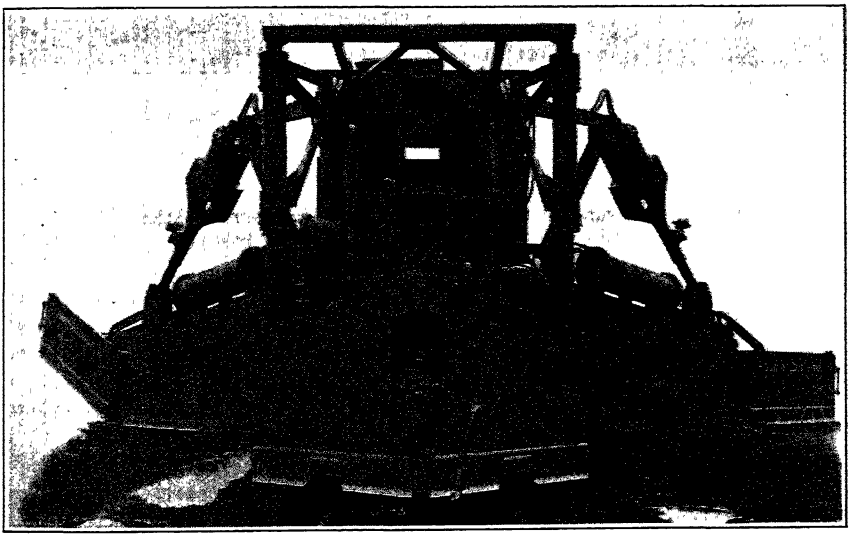
Comments on Wing Type Machine

It is evident that the wing type Ditching-Spreader has proven satisfactory for the performance of the operations for which it was designed.

In every case the machine received commendation and in one or two instances constructive suggestions were offered such as that the method of applying certain parts might be changed to facilitate their renewal.



WING TYPE DITCHING-SPREADER.

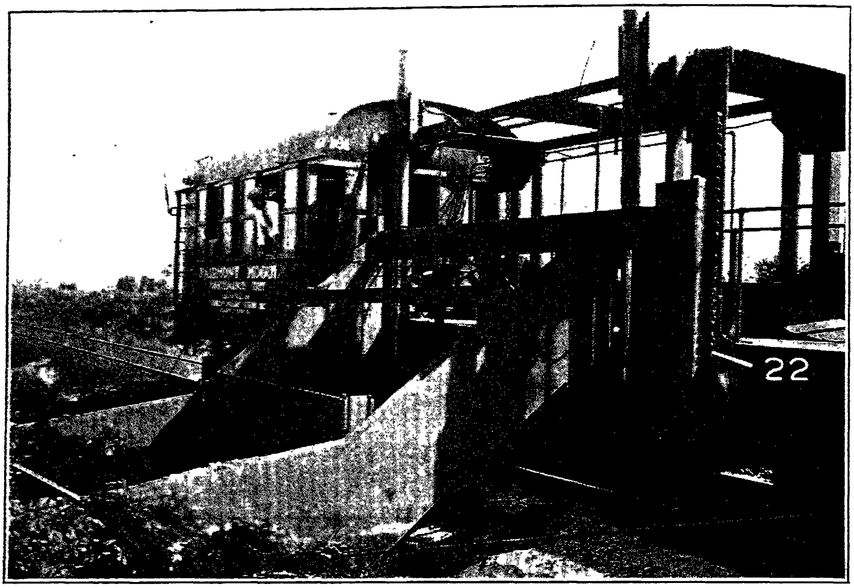


WING TYPE DITCHING-SPREADER—WINGS EXTENDED.

Comments on Box Type Machine

Comments on the new box type self-propelled Ditcher-Spreader shows that the Maintenance Engineers are watching its development with keen interest.

The machine, in its present stage of development, is not designed for heavy cutting but rather for cutting light ditches and cleaning ditches already cut. Although additional tractive power can be applied and several appliances can be added which would allow for operations other than ditching and spreading.



Box Type Ditching-Spreader.

Conclusions

The Committee recommends that the report be received as information.

REPORT OF COMMITTEE XVII—WOOD PRESERVATION

F. C. SHEPHERD, *Chairman;*
W. G. ATWOOD,
R. S. BELCHER,
Z. M. BRIGGS,
WALTER BUEHLER,
C. S. BURT,
G. B. CAMPBELL,
H. R. CONDON,
C. C. COOK,
G. M. CORNELL,
E. A. CRAFT,
H. R. DUNCAN,
E. B. FULKS,
W. R. GOODWIN,
C. W. GREENE,
L. H. HARPER,
L. B. HOLT,
G. R. HOPKINS,
H. E. HORROCKS,
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M. F. JAEGER,
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F. C. KRELL,
A. J. LOOM,
W. T. MACCART,
G. P. MACLAREN,
C. F. FORD, *Vice-Chairman;*
F. D. MATTOS,
CLYDE OSBORNE,
J. H. REEDER,
L. J. REISER,
L. B. SHIPLEY,
O. C. STEINMAYER,
G. C. STEPHENSON,
T. H. STRATE,
W. A. SUMMERHAYS,
C. M. TAYLOR,
DR. H. VON SCHRENK,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) Service Test Records for Treated Ties (Appendix B).

(3) Piling Used for Marine Construction (Appendix C).

(4) Specifications for Treatment of Air Seasoned Douglas Fir (Appendix D).

(5) Destruction by Termite and possible ways of prevention (Appendix E).

(6) Methods of protection of treated materials in the field, collaborating with Committee III—Ties, and Committee VII—Wooden Bridges and Trestles (Appendix F).

(7) Cooperate with the Bureau of Standards and the Committees of the American Society for Testing Materials and American Wood Preservers' Association with the view of developing suitable tables of factors of expansion for coal-tar, petroleum, creosote coal-tar solution, and creosote petroleum mixtures for such ranges of temperature as are of interest to the users of treated timber (Appendix G).

Action Recommended

1. That the information contained in Appendix A, Revision of Manual, be approved for publication in the Manual.

2. That the information contained in Appendix B, Service Test Records for Treated Ties; Appendix C, Piling Used for Marine Construction; Appendix D, Specifications for Treatment of Air Seasoned Douglas Fir; Appendix E, Destruction by Termite and possible ways of Prevention, and Appendix F, Methods of Protection of Treated Materials in the Field, collaborating with Committee III—Ties, and Committee VII—Wooden Bridges and Trestles, be accepted as information.

3. That the information contained in Appendix G, Cooperate with the Bureau of Standards and the Committees of the American Society for Testing Materials and American Wood Preservers' Association, with a view of developing suitable tables of factors of expansion for coal-tar, petroleum, creosote coal-tar solution, and creosote petroleum mixtures for such ranges of temperature as are of interest to the users of treated timber, be accepted and this subject be discontinued.

Respectfully submitted,

THE COMMITTEE ON WOOD PRESERVATION,

F. C. SHEPHERD, *Chairman.*

Bulletin 352, December, 1932.

Appendix A

(1) REVISION OF MANUAL

O. C. Steinmayer, Chairman, Sub-Committee; E. B. Fulks, R. S. Belcher, C. S. Burt, Walter Buehler, C. W. Greene, M. F. Jaeger, H. E. Horrocks, F. D. Mattos, G. C. Stephenson, L. B. Shipley, Dr. Hermann von Schrenk.

(I)

For the past several years consideration has been given to the serious differences in results that are encountered when creosote is distilled at localities differing widely in altitude. At 5,000 feet as compared with sea level, the temperature readings are from 8 to 11 degrees lower, the differences increasing as the temperatures rise. Comparative distillation tests under the direction of Mr. Belcher were made at two Santa Fe plants, namely, Somerville, Texas, altitude 250 feet, and at Albuquerque, New Mexico, altitude 4,943 feet. The same operator made the test at both places, using the same oil samples and apparatus for distillation. Mr. Ernest Bateman of the Forest Products Laboratory prepared a theoretical temperature correction table based on 5,000 feet elevation for Mr. Belcher at that time. The Santa Fe results were in very close agreement with the calculated temperatures. Similar tests were made at two treating plants of the Southern Pacific located at West Oakland, California, at sea level, and at Alamagorda, New Mexico, altitude 4,320 feet. The results of these tests were in close agreement with those of the Santa Fe.

These observations and calculations have been reported in detail in the Proceedings of the American Wood Preservers' Association for 1926 and 1927, and it seems hardly necessary to repeat them at this time. The American Wood Preservers' Association recently has given its approval to a table to be used for eliminating these differences.

Your Committee therefore recommends that the Manual be revised by the insertion, after the paragraph on page 1302, ending on line 21 with the word "centigrade", the following table:

Temperatures at Which Fractions Should Be Cut to Correct Distillation Temperatures for Different Altitudes

Corrections are made to the nearest 1°C.

Elevation above sea level in feet	Fractionation temperatures for various altitudes					
0	200°C.	210°C.	235°C.	270°C.	315°C.	355°C.
1,000	198	208	233	268	313	353
1,500	197	207	232	267	312	352
2,000	196	206	231	266	311	351
2,500	196	206	230	265	310	350
3,000	195	205	230	264	309	349
3,500	194	204	229	263	308	348
4,000	193	203	228	263	307	347
4,500	193	202	227	262	306	346
5,000	192	202	226	261	305	344
5,500	191	201	225	260	304	343
6 000	190	200	225	260	303	343

(II)

It will be recalled that for the past six years a Joint Committee composed of representatives of the American Wood Preservers' Association, the American Railway Engineering Association, and the American Society for Testing Materials has been cooperating with the Bureau of Standards in an endeavor to develop suitable correction factors for the changes in the volume and specific gravity of creosote oil with temperature. All of this work has been done at the Bureau of Standards and our Association is very deeply indebted to them for the admirable cooperation they have given this work.

The first work involved a study of some nine samples of creosote oil and solutions of different origin and resulted in the present tables for distillate oils. At this time it was felt that we did not have sufficient samples to cover the subject of creosote-coal tar solutions or coke oven tars. To secure the necessary information seven representative samples of coke oven tar were submitted and studied, and in addition samples of creosote-coal tar solution of different tar content were investigated.

As a result of this work, the Bureau of Standards prepared tables to be used in making corrections in volume and specific gravity of creosote, creosote coal-tar solution, and coal tar. The use of these tables has been approved by the American Society for Testing Materials, and by the American Wood Preservers' Association.

Your Committee recommends the withdrawal from the Manual of the table of factors shown in the Supplement to the Manual, Bulletin 327, pages 82 to 86 inclusive, and the substitution therefor of the following tables:

Table I.—Volume Correction Table for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar

The observed volume is to be multiplied by the factor corresponding to the observed temperatures

Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature			Observed Temperature, deg. Fahr	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
220	0.9526	0.9542	0.9594	165	0.9743	0.9754	0.9783
219	0.9530	0.9546	0.9597	164	0.9747	0.9758	0.9786
218	0.9534	0.9550	0.9600	163	0.9751	0.9762	0.9789
217	0.9538	0.9554	0.9604	162	0.9754	0.9765	0.9793
216	0.9542	0.9557	0.9607	161	0.9758	0.9769	0.9796
215	0.9546	0.9561	0.9611	160	0.9762	0.9773	0.9800
214	0.9550	0.9565	0.9614	159	0.9766	0.9777	0.9803
213	0.9554	0.9569	0.9618	158	0.9770	0.9781	0.9806
212	0.9558	0.9573	0.9621	157	0.9774	0.9785	0.9810
211	0.9561	0.9577	0.9625	156	0.9778	0.9788	0.9813
210	0.9565	0.9581	0.9628	155	0.9782	0.9792	0.9816
209	0.9569	0.9584	0.9632	154	0.9786	0.9796	0.9820
208	0.9573	0.9588	0.9635	153	0.9790	0.9800	0.9823
207	0.9577	0.9592	0.9639	152	0.9794	0.9804	0.9827
206	0.9581	0.9596	0.9642	151	0.9798	0.9808	0.9830
205	0.9585	0.9600	0.9646	150	0.9802	0.9811	0.9833
204	0.9589	0.9604	0.9649	149	0.9806	0.9815	0.9837
203	0.9593	0.9608	0.9652	148	0.9810	0.9819	0.9840
202	0.9597	0.9611	0.9656	147	0.9814	0.9823	0.9844
201	0.9601	0.9615	0.9659	146	0.9618	0.9827	0.9847
200	0.9605	0.9619	0.9663	145	0.9822	0.9830	0.9850
199	0.9609	0 9623	0.9666	144	0.9826	0.9834	0.9854
198	0.9612	0.9627	0.9670	143	0.9830	0.9838	0.9857
197	0.9616	0.9631	0.9673	142	0.9834	0.9842	0.9860
196	0.9620	0.9634	0.9677	141	0.9838	0.9846	0.9864
195	0.9624	0.9638	0.9680	140	0.9842	0.9850	0.9867
194	0.9628	0.9642	0.9584	139	0.9846	0.9853	0.9870
193	0.9632	0.9646	0.9687	138	0.9850	0.9857	0.9874
192	0.9636	0.9650	0.9690	137	0.9853	0.9861	0.9877
191	0.9640	0.9654	0.9694	136	0.9857	0.9865	0.9880
190	0.9644	0.9658	0.9697	135	0.9861	0.9868	0.9884
189	0.9648	0.9662	0.9701	134	0.9865	0.9872	0.9887
188	0.9652	0.9665	0.9704	133	0.9869	0.9876	0.9890
187	0.9656	0.9669	0.9708	132	0.9873	0.9880	0.9894
186	0.9660	0.9673	0.9711	131	0.9877	0.9884	0.9897
185	0.9664	0.9677	0.9714	130	0.9881	0.9887	0.9900
184	0.9668	0.9681	0.9718	129	0.9885	0.9891	0.9904
183	0.9672	0.9685	0.9721	128	0.9889	0.9895	0.9907
182	0.9676	0.9688	0.9725	127	0.9893	0.9899	0.9910
181	0.9680	0.9692	0.9728	126	0.9897	0.9902	0.9914
180	0.9684	0.9696	0.9732	125	0.9901	0.9906	0.9917
179	0.9687	0.9700	0.9735	124	0.9905	0.9910	0.9920
178	0.9691	0.9704	0.9739	123	0.9909	0.9914	0.9924
177	0.9695	0.9708	0.9742	122	0.9913	0.9917	0.9927
176	0.9699	0.9712	0.9745	121	0.9917	0.9921	0.9930
175	0.9703	0.9715	0.9749	120	0.9921	0.9925	0.9934
174	0.9707	0.9719	0.9752	119	0.9925	0.9929	0.9937
173	0.9711	0.9723	0.9756	118	0.9929	0.9932	0.9940
172	0.9715	0.9727	0.9759	117	0.9932	0.9936	0.9944
171	0.9719	0.9731	0.9762	116	0.9936	0.9940	0.9947
170	0.9723	0.9735	0.9766	115	0.9940	0.9944	0.9950
169	0.9727	0.9738	0.9769	114	0.9944	0.9948	0.9954
168	0.9731	0.9742	0.9772	113	0.9948	0.9951	0.9957
167	0.9735	0.9746	0.9776	112	0.9952	0.9955	0.9960
166	0.9739	0.9750	0.9779	111	0.9956	0.9959	0.9964

TABLE I.—*(Continued)*

The observed volume is to be multiplied by the factor corresponding to the observed temperatures

Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature			Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
110	0.9960	0.9962	0.9967	105	0.9980	0.9981	0.9983
109	0.9964	0.9966	0.9970	104	0.9984	0.9985	0.9987
108	0.9968	0.9970	0.9974	103	0.9988	0.9989	0.9990
107	0.9972	0.9974	0.9977	102	0.9992	0.9992	0.9993
106	0.9976	0.9978	0.9980	101	0.9996	0.9996	0.9997
				100	1.0000	1.0000	1.0000

The portion of the table below should not be used unless the oil is entirely free from crystals.

Observed Temperature, deg. Fahr.	Creosote	Solution	Coal Tar	Observed Temperature, deg. Fahr.	Creosote	Solution	Coal Tar
99	1.0004	1.0004	1.0003	79	1.0083	1.0079	1.0070
98	1.0008	1.0008	1.0007	78	1.0087	1.0082	1.0073
97	1.0012	1.0011	1.0010	77	1.0091	1.0086	1.0076
96	1.0016	1.0015	1.0013	76	1.0095	1.0090	1.0080
95	1.0020	1.0019	1.0017	75	1.0099	1.0094	1.0083
94	1.0024	1.0022	1.0020	74	1.0103	1.0097	1.0086
93	1.0028	1.0026	1.0023	73	1.0107	1.0101	1.0089
92	1.0032	1.0030	1.0026	72	1.0111	1.0105	1.0093
91	1.0036	1.0034	1.0030	71	1.0115	1.0109	1.0096
90	1.0040	1.0038	1.0033	70	1.0118	1.0112	1.0099
89	1.0043	1.0041	1.0036	69	1.0122	1.0116	1.0103
88	1.0047	1.0045	1.0040	68	1.0126	1.0120	1.0106
87	1.0051	1.0049	1.0043	67	1.0130	1.0124	1.0109
86	1.0055	1.0052	1.0046	66	1.0134	1.0127	1.0112
85	1.0059	1.0056	1.0050	65	1.0138	1.0131	1.0116
84	1.0063	1.0060	1.0053	64	1.0142	1.0135	1.0119
83	1.0067	1.0064	1.0056	63	1.0146	1.0138	1.0122
82	1.0071	1.0067	1.0060	62	1.0150	1.0142	1.0126
81	1.0075	1.0071	1.0063	61	1.0154	1.0146	1.0129
80	1.0079	1.0075	1.0066	60	1.0158	1.0150	1.0132

TABLE II.—SPECIFIC GRAVITY CORRECTION TABLE FOR CREOSOTE, CREOSOTE COAL-TAR SOLUTION (UP TO 50 PER CENT TAR) AND COAL TAR

Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity			Observed Temperature, deg. Fahr	Add to Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
220	0.0491	0.0481	0.0451	160	0.0244	0.0238	0.0223
219	0.0487	0.0477	0.0447	159	0.0239	0.0234	0.0219
218	0.0483	0.0473	0.0443	158	0.0234	0.0230	0.0216
217	0.0479	0.0469	0.0439	157	0.0230	0.0226	0.0212
216	0.0475	0.0465	0.0436	156	0.0226	0.0222	0.0208
215	0.0471	0.0460	0.0432	155	0.0222	0.0218	0.0204
214	0.0467	0.0456	0.0428	154	0.0218	0.0214	0.0200
213	0.0462	0.0452	0.0424	153	0.0214	0.0210	0.0197
212	0.0458	0.0448	0.0420	152	0.0210	0.0206	0.0193
211	0.0454	0.0444	0.0417	151	0.0206	0.0202	0.0189
210	0.0450	0.0440	0.0413	150	0.0202	0.0198	0.0186
209	0.0446	0.0436	0.0409	149	0.0198	0.0194	0.0182
208	0.0442	0.0432	0.0405	148	0.0194	0.0190	0.0178
207	0.0438	0.0428	0.0401	147	0.0189	0.0186	0.0174
206	0.0434	0.0424	0.0398	146	0.0186	0.0182	0.0170
205	0.0430	0.0420	0.0394	145	0.0182	0.0178	0.0167
204	0.0426	0.0416	0.0390	144	0.0177	0.0174	0.0163
203	0.0422	0.0412	0.0386	143	0.0173	0.0170	0.0159
202	0.0418	0.0408	0.0382	142	0.0169	0.0166	0.0155
201	0.0413	0.0404	0.0379	141	0.0165	0.0162	0.0152
200	0.0409	0.0400	0.0375	140	0.0161	0.0158	0.0148
199	0.0405	0.0396	0.0371	139	0.0157	0.0154	0.0144
198	0.0401	0.0392	0.0367	138	0.0153	0.0150	0.0141
197	0.0397	0.0388	0.0363	137	0.0149	0.0146	0.0137
196	0.0392	0.0384	0.0360	136	0.0145	0.0142	0.0133
195	0.0388	0.0379	0.0356	135	0.0141	0.0138	0.0130
194	0.0384	0.0375	0.0352	134	0.0137	0.0134	0.0126
193	0.0380	0.0371	0.0348	133	0.0133	0.0130	0.0122
192	0.0375	0.0367	0.0344	132	0.0129	0.0126	0.0118
191	0.0371	0.0363	0.0341	131	0.0125	0.0122	0.0115
190	0.0367	0.0359	0.0337	130	0.0121	0.0118	0.0111
189	0.0363	0.0355	0.0333	129	0.0117	0.0114	0.0107
188	0.0359	0.0351	0.0329	128	0.0113	0.0110	0.0104
187	0.0355	0.0347	0.0325	127	0.0109	0.0106	0.0100
186	0.0351	0.0343	0.0322	126	0.0105	0.0102	0.0096
185	0.0347	0.0339	0.0318	125	0.0101	0.0098	0.0092
184	0.0343	0.0335	0.0314	124	0.0097	0.0094	0.0089
183	0.0339	0.0331	0.0310	123	0.0093	0.0090	0.0085
182	0.0334	0.0327	0.0306	122	0.0089	0.0087	0.0081
181	0.0330	0.0323	0.0303	121	0.0084	0.0083	0.0078
180	0.0326	0.0319	0.0299	120	0.0080	0.0079	0.0074
179	0.0322	0.0315	0.0295	119	0.0076	0.0075	0.0070
178	0.0318	0.0311	0.0291	118	0.0072	0.0071	0.0067
177	0.0314	0.0307	0.0288	117	0.0068	0.0067	0.0063
176	0.0309	0.0303	0.0284	116	0.0064	0.0063	0.0059
175	0.0305	0.0298	0.0280	115	0.0060	0.0059	0.0056
174	0.0301	0.0294	0.0276	114	0.0056	0.0055	0.0052
173	0.0297	0.0290	0.0272	113	0.0052	0.0051	0.0048
172	0.0293	0.0286	0.0269	112	0.0048	0.0047	0.0044
171	0.0289	0.0282	0.0265	111	0.0044	0.0043	0.0041
170	0.0284	0.0278	0.0261	110	0.0040	0.0039	0.0037
169	0.0280	0.0274	0.0257	109	0.0036	0.0035	0.0033
168	0.0276	0.0270	0.0254	108	0.0032	0.0031	0.0030
167	0.0272	0.0266	0.0250	107	0.0028	0.0027	0.0026
166	0.0268	0.0262	0.0246	106	0.0024	0.0023	0.0022
165	0.0264	0.0258	0.0242	105	0.0020	0.0020	0.0018
164	0.0260	0.0254	0.0238	104	0.0016	0.0016	0.0015
163	0.0256	0.0250	0.0234	103	0.0012	0.0012	0.0011
162	0.0252	0.0246	0.0231	102	0.0008	0.0008	0.0007
161	0.0248	0.0242	0.0227	101	0.0004	0.0004	0.0004
				100	0.0000	0.0000	0.0000

TABLE II.—*(Continued)*

The portion of the table below should not be used unless the oil is entirely free from crystals

Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity			Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
99	0.0004	0.0004	0.0004	79	0.0083	0.0082	0.0077
98	0.0008	0.0008	0.0007	78	0.0087	0.0086	0.0081
97	0.0012	0.0012	0.0011	77	0.0091	0.0090	0.0085
96	0.0016	0.0016	0.0015	76	0.0095	0.0094	0.0088
95	0.0020	0.0020	0.0018	75	0.0099	0.0097	0.0092
94	0.0024	0.0023	0.0022	74	0.0103	0.0101	0.0096
93	0.0028	0.0027	0.0026	73	0.0107	0.0105	0.0099
92	0.0032	0.0031	0.0030	72	0.0111	0.0109	0.0102
91	0.0036	0.0035	0.0033	71	0.0115	0.0113	0.0106
90	0.0040	0.0039	0.0037	70	0.0118	0.0117	0.0109
89	0.0043	0.0043	0.0040	69	0.0122	0.0121	0.0113
88	0.0047	0.0047	0.0044	68	0.0126	0.0124	0.0117
87	0.0051	0.0051	0.0048	67	0.0130	0.0128	0.0120
86	0.0055	0.0055	0.0052	66	0.0134	0.0132	0.0124
85	0.0059	0.0058	0.0055	65	0.0138	0.0136	0.0128
84	0.0063	0.0062	0.0059	64	0.0142	0.0140	0.0132
83	0.0067	0.0066	0.0063	63	0.0146	0.0144	0.0135
82	0.0071	0.0070	0.0066	62	0.0150	0.0148	0.0139
81	0.0075	0.0074	0.0070	61	0.0154	0.0152	0.0143
80	0.0079	0.0078	0.0074	60	0.0158	0.0155	0.0146

Appendix B

(2) SERVICE TEST RECORDS FOR TREATED TIES

W. R. Goodwin, Chairman, Sub-Committee; Z. M. Briggs, C. S. Burt, E. A. Craft, C. W. Greene, L. B. Holt, R. S. Hubley, F. C. Krell, G. P. MacLaren, W. T. MacCart, T. H. Strate, J. H. Reeder.

The table of tie renewals per mile maintained on various railroads has been revised to include renewals for 1931.

In requesting this information we also asked the two following questions:

1. Do you adze and bore your ties before treatment, and if so when did you begin?
2. What is your standard length of cross-tie?

The answers are shown in the table below:

	Adze and Bore Yes or No	*When*	*Length*		*Adze and Bore Yes or No*	*When*	*Length*
Santa Fe	Yes	1912	8′	MKT	Yes	1926	8′
B&O	No		8′6″	Monon	No		8′
C&EI	No		8′	NYC—East	Yes		8′6″
CCC&StL	Yes	1925	8′6″ and 8′	" —West	Yes	1926	8′6″
CRI&P	Yes	1913	8′	NP	Yes	1911	8′6″
DL&W	Yes	1911	8′6″	Penn.	No		8′6″
GN	Yes	1925	8′6″	Soo	Yes	1925	8′
IC	Yes	1924	8′ and 8′6″	Sou. Pac. Atl.	Yes	1924	8′
KCS	Yes	1926	8′	UP	Yes	1928	8′
LV	Yes	1929	8′6″	CNJ	Yes	1912	8′6″
Mich. Central	Yes		8′6″	Reading	Yes	1912	8′6″
				C&O	Yes	1925	8′6″

Reports are submitted covering special test tracks on the B.&O., C.B.&Q., C.R.I.&P., G.N., U.P. railways and the City of Minneapolis Filtration Plant Ry.

CITY OF MINNEAPOLIS, MINNESOTA FILTRATION PLANT RAILWAY

4200—6" x 8"—8' Red Oak Cross-Ties
Treated September and October 1916
Average absorption 10.08 lb. per cu. ft. Creosote-Tar Mixture, 40 per cent M. of W. Creosote, 20 per cent Coke Oven Tar, and 40 per cent Water Gas Tar

Analyses

	Treating Mixture 40–20–40 *Actual*	*Computed*	*M. of W. Creosote*	*Coke Oven Tar*	*Water Gas Tar*
Distillation to 170°C	0.9%	....	....	....	....
210°C	2.5%	2.2	0.1	0.5	5.2
235°C	12.8	12.1	13.4	5.7	14.1
315°C	41.1	41.5	51.8	19.1	42.4
355°C	56.6	57.8	72.1	29.0	58.0
Sp. Gr. @ 380°C	1.111	Sp. Gr. @ 60°F	1.096	1.207	1.093
Water	1.8%		0.6%	1.9%	0.2%

Sp. Gr. 235°–315° Fraction—1.024 at 60°C/60°C.

The City Engineer of Minneapolis, N. W. Elsberg, reports that none of these ties have been removed to date, i.e., 16 years' service.

GREAT NORTHERN RAILWAY

Summary Statement—1932

Creosoted White Birch Test Ties Placed in Track Spring of 1908

Division	*Number Originally Placed*	*Number Now in Service*	*Number Removed From all Causes*	*Per Cent Removed*	*Estimated Average Expected Life* Years	*Average Life of Untreated Birch* Years
Main Lines						
Ties 7" x 7"—8'						
Mesabi	1410	821	589	41.8	26	5
Willmar	586	434	152	26.0	29	5
Dakota	2214	1261	953	43.0	26	5
Minot	1391	568	823	58.8	23	5
Butte	1070*	621	449	42.0	26	5
Total	6671*	3705	2966	44.5	25	5
Branch Lines						
Ties 6" x 7"—8'						
Mesabi .... (Princeton Line)	1419	612	807	56.9	23	5
(Park Rapids Line)	1447	962	485	33.5	27	5
Total	2866	1574	1292	45.1	25	5
Grand Total ..	9537	5279	4258	44.6	25	5

* Reduced 370 on account of ties removed from Saco Siding with abandonment of tracks in 1916. Ties were in excellent condition when removed.

THE BALTIMORE & OHIO RAILROAD

Report on Herring Run, Md. Special Test Track
1932 Inspection

Kind of Wood—Red Oak

Age of Test—Eighteen Years

Sec. No.	Tie Numbers	Process	Treatment Per Cu.Ft.	Ties Placed	Ties in Test	Removed to Date No.	Removed to Date Per Cent	Average Life to Date of Ties in Test
				Note	Note			
				298	289	289	100.0	5.1
1	3–300	Untreated	0.35 lb. Zinc Chl.	300	161	147	91.3	12.5
2	301–600	Burnettizing	0.63 lb. " "	300	211	134	63.5	14.3
3	601–900	"	4.02 lb. Creosote	300	300	150	50.0	15.6
4	901–1200	Straight Cr.	9.78 lb. "	300	300	21	7.0	17.7
5	1201–1500	" "	5.16 lb. W.G. Tar Cr.	150	150	81	54.0	16.0
6	1501–1650	Straight W.G.						
		Tar Creo.	6.12 lb. W.G. Tar Cr.	150	150	69	46.0	16.2
7	1651–1800	Straight W.G.						
		Tar Creo.	7.09 lb. W.G. Tar Cr.	150	150	108	72.0	14.6
8	1801–1950	Straight W.G.						
		Tar Creo.	10.90 lb. W.G. Tar Cr.	150	150	86	57.3	15.6
9	1951–2100	Straight W.G.						
		Tar Creo.	11.00 lb. W.G. Tar Cr.	212	211	149	70.6	14.3
10	0–212 Cull	Straight W.G.						
		Tar Creo.	0.41 lb. Sodium					
11	2101–2400	Sodium	Fluoride	300	300	262	87.3	14.4
		Fluoride	0.63 lb. Zinc Chl.	300	300	277	92.3	13.1
12	2401–2700	Card	0.76 lb. Creosote					
			0.69 lb. Zinc Chl.	300	300	186	62.0	15.2
13	2701–3000	Card	1.35 lb. W.G. Tar Cr.					
			0.37 lb. Creosote					
			0.5 lb. Zinc Chlor. ...	300	288	244	84.7	13.0
14	3001–3300	Card	2.0 lb. Creosote					

Note.—The difference between "Ties Placed" and "Ties in Test" is due to elimination from test of ties account of removals from derailments and installation of switches.

—This group installed 9 months (.75 year) after other ties in this test.

Traffic and Climate

	Annual Average
Traffic—Gross Tons (Thousands)	17,501
Temperature—Mean January	35.0
Fahrenheit—Mean July	77.5
Highest Annual	99.3
Lowest Annual	8.3
Rainfall—Inches	40.0

THE BALTIMORE & OHIO RAILROAD

REPORT ON WINDSOR–BLANCHESTER, OHIO SPECIAL TEST TRACK
1932 INSPECTION

Age of Tie Test—22 Years

Treatment and Kind of Wood	Ties Placed	Ties in Test	Removed to Date No.	Removed to Date %	Av. Life to Date of Ties in Test	Remaining in Trk. Est. Add'l. Ave. Life No.	Remaining in Trk. Est. Add'l. Ave. Life Years	Anticipated Av. Total Life of all Ties in Test
	Note	Note						
UNTREATED								
White Oak	757	757	747	98.7	10.2	10	1.9	10.3
STRAIGHT CREOSOTE								
Red Oak	873	820	78	9.5	21.5	742	2.7	23.3
*Other Woods	252	252	121	46.9	18.0	131	4.4	20.0
CARD PROCESS								
Red Oak	1125	1125	486	43.2	19.3	639	2.6	20.4
*Other Woods	1219	1206	740	61.4	18.2	466	2.3	17.9
TIMBER ASPHALT								
Red Oak	984	969	962	99.2	10.7	7	2.3	10.7

NOTE.—The difference between "Ties Placed" and "Ties in Test" is due to elimination from test of ties account of removals from derailments.

* Other Woods—Beech, Hard Maple, Gum and Elm.

TRAFFIC AND CLIMATE

		Annual Average
Traffic—Gross Tons (Thousands)		5,148
Temperature—Mean January		30.8
(Fahrenheit)—Mean July		74.5
	—Highest Annual	96.2
	—Lowest Annual	—5.1
Rainfall	—Inches	40.6

Conclusion

It is recommended that this report be accepted as information.

CHICAGO, BURLINGTON & QUINCY RAILROAD

Process	Lines East: Total Placed	Lines East: Total Removed to date	Lines East: % Removed a/c decay	Lines East: % Removed other causes	Lines East: Est. Yrs. Av. Life	Lines West: Total Placed	Lines West: Total Removed to date	Lines West: % Removed a/c decay	Lines West: % Removed other causes	Lines West: Est. Yrs. Av. Life
WHITE OAK TIES										
Straight Creosote	25	2	0	8%	44	15	9	20%	40%	21
Card	234	207	38%	51%	15	152	128	28%	56%	17
Burnett	28	26	54%	39%	15	15	15	40%	60%	16.3
Untreated	81	81	88%	12%	11	44	43	80%	19%	14
RED OAK TIES										
Straight Creosote	165	51	2%	29%	27	120	58	12%	37%	23
Card	776	490	17%	46%	21	510	455	32%	58%	15
Burnett	158	133	42%	42%	17	116	109	41%	54%	14
Untreated	129	129	96%	4%	5.5	75	75	93%	7%	5.5
PIN OAK TIES										
Straight Creosote	189	49	3%	23%	28	133	34	7%	19%	28
Card Process	513	275	14%	40%	22	321	220	23%	46%	20
Burnett	23	10	13%	30%	24	44	43	32%	66%	14
Untreated	81	80	95%	4%	13	45	45	98%	2%	7
POPLAR TIES										
Straight Creosote	50	20	8%	32%	25	30	24	17%	63%	18
Card	396	337	36%	49%	16	253	218	37%	49%	16
Burnett	50	48	42%	54%	14	30	30	57%	43%	14
Untreated	81	81	94%	6%	6	45	45	96%	4%	6
RED GUM TIES										
Straight Creosote	89	53	25%	35%	21	48	31	27%	38%	20
Card	429	282	28%	37%	20	233	150	33%	32%	20
Burnett	75	73	64%	33%	14	43	41	70%	26%	14
Untreated	98	98	97%	3%	4	54	54	98%	2%	4
SYCAMORE TIES										
Straight Creosote	75	26	19%	19%	26	15	2	0	13%	36
Card	399	226	35%	22%	22	121	110	62%	29%	15
Burnett	75	73	69%	28%	14	15	15	80%	20%	14.5
Untreated	81	81	98%	2%	4	50	50	96%	4%	4
TAMARACK TIES										
Straight Creo.	106	65	7%	55%	21	108	81	13%	62%	19
Card	813	688	19%	66%	16	494	436	30%	58%	18
Burnett	108	91	37%	47%	17	106	101	30%	65%	14
Untreated	98	98	96%	4%	5.5	77	77	99%	1%	5.5
TUPELO GUM TIES										
Straight Creo.	99	51	19%	32%	23	54	30	20%	35%	22
Card	436	211	12%	36%	23	237	73	13%	18%	27
Burnett	76	73	45%	51%	14	41	41	61%	39%	14.1
Untreated	88	88	98%	2%	4	48	48	98%	2%	4

CHICAGO, BURLINGTON & QUINCY RAILROAD
TOTAL TIES, VARIOUS KINDS, VARIOUS PROCESSES, PLACED IN
EXPERIMENTAL TRACKS 1909 and 1910

SUMMARY - 1931 INSPECTION

Process	Lines East: Total Placed	Lines East: Total removed to date	Lines East: % removed acct. decay	Lines East: % removed a/c other causes	Lines East: Estimated years av. life	Lines West: Total Placed	Lines West: Total removed to date	Lines West: % removed acct. decay	Lines West: % removed a/c other causes	Lines West: Estimated years av. life
Straight Creosote	2046	795	12%	27%	24.8	1237	600	15%	34%	23
Card	10243	7158	24%	45%	19.67	5591	4378	29%	49%	18.17
Burnett	1578	1380	47%	41%	16	909	864	46%	49%	14.33
Untreated	2045	2039	89%	10%	5.8	1226	1224	90%	9%	5.5
Total Treated	13867	7333	25%	42%	20	7737	5842	29%	47%	18.5
Grand Total	15912	11372	33%	38%	19	8963	7066	37%	42%	18

NOTE: We have included in these percentages only the ties placed in what we term the thousand tie lots on the various divisions

Chicago, Burlington & Quincy Railroad

	LINES EAST					LINES WEST				
Process	Total Placed	Total Removed to date	% Removed a/c decay	% Removed Other Causes	Est. Yrs. Av. Life	Total Placed	Total Removed To Date	% Removed a/c decay	% Removed Other causes	Est. Yrs. Av. Life
					ASH TIES					
Straight Creosote	19	16	26%	58%	17	15	10	20%	47%	20
Card	289	214	13%	61%	19	103	78	18%	57%	19
Burnett	16	12	31%	44%	19	15	13	33%	53%	15
Untreated	70	70	99%	1%	5.5	46	46	100%	0	5.5
					BEECH TIES					
Straight Creosote	321	65	5%	16%	30	163	45	6%	22%	27
Card	807	661	37%	44%	17.5	418	349	38%	46%	17
Burnett	210	184	48%	40%	16	105	96	50%	41%	15
Untreated	134	134	98%	2%	5	74	74	93%	7%	5
					BIRCH TIES					
Straight Creosote	75	34	32%	13%	24	59	24	14%	27%	24.5
Card	715	506	30%	41%	19	360	299	32%	51%	17
Burnett	73	73	48%	52%	12.9	30	30	47%	53%	15.4
Untreated	139	139	99%	1%	4	78	78	100%	0	4
					CHESTNUT TIES					
Straight Creosote	0	0	0	0	0	0	0	0	0	0
Card	164	161	16%	82%	14	89	89	9%	91%	10.2
Burnett	0	0	0	0	0	0	0	0	0	0
Untreated	189	167	27%	72%	13	90	89	21%	78%	13
					COTTONWOOD TIES					
Straight Creosote	98	27	1%	30%	27	45	14	13%	18%	27
Card	296	197	22%	45%	20	150	123	23%	54%	18
Burnett	0	0	0	0	0	0	0	0	0	0
Untreated	56	56	95%	5%	3	30	30	100%	0	3
					CYPRESS TIES					
Straight Creosote	25	5	0	20%	30	29	20	45%	24%	20
Card	402	282	9%	61%	19.5	254	196	24%	53%	18
Burnett	25	15	0	60%	21	30	29	47%	50%	14
Untreated	135	132	98%	20%	14	90	90	89%	11%	8.5
					ELM TIES					
Straight Creosote	208	64	12%	19%	27	120	37	8%	23%	27
Card	594	339	19%	38%	22	371	228	25%	37%	21
Burnett	224	171	33%	44%	18	73	66	56%	34%	15
Untreated	113	113	91%	9%	5.5	78	78	96%	4%	5.5
					HEMLOCK TIES					
Straight Creosote	136	91	24%	43%	20	99	78	23%	56%	18
Card	815	613	24%	51%	19	488	433	36%	52%	16
Burnett	125	103	41%	42%	17	87	79	33%	57%	15
Untreated	112	112	100%	0	6	78	78	99%	1%	6
					HICKORY TIES					
Straight Creosote	10	2	10%	10%	30	15	6	7%	33%	25
Card	185	170	30%	62%	15	106	93	39%	50%	15.5
Burnett	9	6	0	67%	20	15	14	47%	47%	14.5
Untreated	65	65	89%	11%	6	45	45	100%	0	6
					PINE TIES - LOBLOLLY SAP					
Straight Creosote	145	51	3%	34%	25	72	49	17%	51%	20
Card	949	503	23%	40%	21	386	310	24%	57%	17.5
Burnett	128	126	73%	25%	13	72	72	46%	54%	12.4
Untreated	157	157	99%	1%	6	91	91	100%	0	6
					HARD MAPLE TIES					
Straight Creosote	82	27	22%	11%	26	34	19	47%	9%	22
Card	561	335	26%	33%	21.5	272	208	30%	46%	18.5
Burnett	50	39	36%	42%	18	15	15	87%	13%	17.7
Untreated	76	76	99%	1%	5	45	45	100%	0	5
					SOFT MAPLE TIES					
Straight Creosote	139	93	32%	35%	20	63	29	19%	27%	24
Card	462	361	41%	37%	18	264	182	20%	49%	20
Burnett	125	124	53%	36%	13	57	55	46%	51%	14
Untreated	82	82	99%	1%	4	43	43	95%	5%	4

Sheet #1. ROCK ISLAND LINES

Special Report of Ties in Test Sections - Fall Inspection 1931.

Creosoted Ties "Lowry" Process (1907 to 1912 inclusive)

Divisions	Location	Kind of Ties	Year	No. of Ties: Inserted	No. of Ties: Remaining in Track	Per Cent Removed	Average Life Yrs. End 1931	Estimated Av. Life Yrs. #
C.R.Dak.	Clarksville, Ia.	R.Oak	1907	345	211	38	22.2	27.6
C.R.Dak.	Clarksville, Ia.	Gum	1907	99	54	45	21.7	26.5
Illinois	Tiskilwa, Ill.	R.Oak	1908	514	131	74	19.0	21.3
Ia.Minn.	Altoona, Ia.	"	"	477	329	31	21.1	27.7
Missouri	Princeton, Mo.	"	"	215	28	87	17.4	19.8
C.R.Dak.	Ely, Ia.	"	"	1178	626	46	20.0	25.2
"	Clarksville, Ia.	"	"	1641	650-	60	20.6	23.2
"	West Bend, Ia.	"	"	149	85	43	19.7	25.5
Neb.Colo.	Fairbury, Neb.	"	"	502	332	33	21.4	27.4
"	Goodland, Kans.	"	"	87	81	7	22.8	##
	Total -	R.Oak	1908	4763	2262	52	20.2	24.4
Illinois	Tiskilwa, Ill.	Gum	1908	71	12	83	16.5	20.3
Missouri	E.Des Moines, Ia.	"	"	99	66	33	20.9	27.4
C.R.Dak.	Ely, Ia.	"	"	391	149	61	18.1	23.0
"	Clarksville Ia.	"	"	95	50	47	20.0	25.0
"	West Bend, Ia.	"	"	887	647	27	20.9	28.4
Neb.Colo.	Fairbury, Nebr.	"	"	114	39	66	19.2	22.3
	Total -	Gum	1908	1657	963	41	19.8	25.8
Illinois	Tiskilwa, Ill.	R.Oak	1909	1340	662	50	19.2	23.6
Ia.Minn.	Altoona, Ia.	"	"	1445	1130	22	20.2	28.2
Missouri	Princeton, Mo.	"	"	399	176	55	19.0	22.7
C.R.Dak.	Ely, Ia.	"	"	971	611	37	20.0	25.2
"	Clarksville, Ia.	"	"	1590	848	46	20.2	24.1
Neb.Colo.	Fairbury, Neb.	"	"	321	276	14	21.4	30.1
"	Goodland, Kans.	"	"	1118	1053	6	21.7	##
Kansas	Topeka, Kans.	"	"	921	437	52	19.5	23.4
	Total -	R.Oak	1909	8105	5193	35	20.2	25.6
Illinois	Tiskilwa, Ill.	Gum	1909	58	32	45	19.5	24.1
Ia.Minn.	Altoona, Ia.	"	"	63	59	6	21.6	##
Missouri	E.Des Moines, Ia.	"	"	596	238	60	18.5	22.2
C.R.Dak.	Ely, Ia.	"	"	126	58	54	19.0	22.9
"	West Bend, Ia.	"	"	539	434	19	20.7	28.5
El.P.Am.	Dalhart, Tex.	"	"	894	726	18	21.1	28.6
	Total -	Gum	1909	2276	1547	32	20.2	26.2
Missouri	E.DesMoines, Ia.	Pine	1909	364	169	53	19.4	23.1
C.R.Dak.	Ely, Ia.	"	"	214	147	31	20.3	26.5
Neb.Colo.	Goodland, Kans.	"	"	136	121	11	21.5	31.4
El.P.Am.	Dalhart, Tex.	"	"	165	129	22	20.9	28.2
	Total -	Pine	1909	879	566	35	20.2	25.6
Illinois	Tiskilwa, Ill.	R.Oak	1910	2860	1836	35	19.4	24.4
Ia.Minn.	Altoona, Ia.	"	"	583	536	8	20.5	##
Missouri	Princeton, Mo.	"	"	997	449	55	18.1	21.6
C.R.Dak.	Ely, Ia.	"	"	2343	1678	28	19.5	25.6
"	Clarksville, Ia.	"	"	1473	934	36	19.9	24.4
Neb.Colo.	Fairbury, Nebr.	"	"	1721	1455	15	20.3	28.3
St.LKCT	Eldon, Mo.	"	"	4129	2768	32	19.5	25.0
Kansas	Topeka, Kans.	"	"	437	194	55	18.5	21.6
	Total -	R.Oak	1910	14543	9850	32	19.5	25.0
Illinois	Tiskilwa, Ill.	Gum	1910	55	38	31	18.5	25.3
Missouri	E.Des Moines, Ia.	"	"	309	131	57	17.5	21.4
C.R.Dak.	Ely, Ia.	"	"	159	88	44	18.2	23.3
"	West Bend, Ia.	"	"	279	233	16	20.2	28.0
	Total -	Gum	1910	802	490	38	18.6	24.1

- Estimated average life based on Forest Products Laboratory Curve

- Estimated average life cannot be determined when renewals to date are less than ten per cent.

Sheet #2. ROCK ISLAND LINES

Special Report of Ties in Test Sections-Fall Inspection 1931.

Creosoted Ties "Lowry" Process (1907 to 1912 inclusive)

Divisions	Location	Kind of Ties	Year	No. of Ties In-sert-ed	No. of Ties Remain-ing in Track	Per Cent Re-moved	Average Life Yrs. End 1931	Estimat-ed Av. Life Yrs. #
Missouri	E. Des Moines, Ia.	Pine	1910	155	113	27	19.5	25.9
C.R.Dak.	Ely, Ia.	"	"	108	68	37	19.1	24.1
"	West Bend, Ia.	"	"	57	54	5	20.6	##
Neb.Colo.	Fairbury, Nebr.	"	"	231	206	10	20.6	##
"	Goodland, Kans.	"	"	727	693	4	20.9	##
Kansas	Topeka, Kans.	"	"	256	131	49	18.6	22.5
	Total -	Pine	1910	1534	1265	17	20.2	28.0
Illinois	Tiskilwa, Ill.	R.Oak	1911	1099	683	37	18.4	22.9
Ia.Minn.	Altoona, Ia.	"	"	763	699	8	19.6	##
Missouri	Princeton, Mo.	"	"	1803	1085	39	18.8	22.7
C.R.Dak.	Ely, Ia.	"	"	2256	1862	17	19.2	26.6
"	West Bend, Ia.	"	"	89	77	13	19.3	27.7
Neb.Colo.	Fairbury, Nebr.	"	"	51	46	10	19.5	##
"	Goodland, Kans.	"	"	105	103	2	19.9	##
	Total -	R.Oak	1911	6166	4555	26	19.0	24.7
Illinois	Tiskilwa, Ill.	Pine	1911	69	44	36	17.2	23.2
Missouri	E.DesMoines, Ia.	"	"	56	39	30	18.2	24.1
C.R.Dak.	Clarksville, Ia.	"	"	1013	890	12	19.6	28.1
"	West Bend, Ia.	"	"	809	757	6	19.5	##
Neb.Colo.	Fairbury, Nebr.	"	"	1496	1333	10	19.4	##
"	Goodland, Kans.	"	"	1603	1401	12	19.6	28.1
Kansas	Topeka, Kans.	"	"	146	106	27	19.5	24.7
	Total -	Pine	1911	5192	4570	12	19.5	28.1
Ia.Minn.	Altoona, Ia.	Gum	1911	299	267	10	19.5	##
Missouri	Princeton, Mo.	"	"	707	388	43	17.7	22.2
C.R.Dak.	Ely, Ia.	"	"	344	237	31	18.7	24.1
Neb.Colo.	Fairbury, Neb.	"	"	67	19	71	16.5	18.8
	Total -	Gum	1911	1417	911	35	18.3	23.2
Illinois	Tiskilwa, Ill.	R.Oak	1912	194	136	29	17.5	23.1
Ia.Minn.	Altoona, Ia.	"	"	750	659	12	17.4	26.7
Missouri	Princeton, Mo.	"	"	331	159	52	14.8	20.2
"	E.DesMoines, Ia.	"	"	5449	4845	11	18.6	27.1
C.R.Dak.	Ely, Ia.	"	"	465	416	10	18.6	##
Neb.Colo.	Goodland, Kans.	"	"	83	80	4	18.9	##
St.LKCT	Eldon, Mo.	"	"	2416	2192	9	18.4	##
	Total -	R.Oak	1912	9688	8487	12	18.3	26.7
C.R.Dak.	Ely, Ia.	Pine	1912	345	278	19	18.5	24.7
"	Clarksville, Ia.	"	"	1037	948	8	18.6	##
"	West Bend, Ia.	"	"	711	681	4	18.7	##
Neb.Colo.	Fairbury, Nebr.	"	"	1370	1226	10	18.7	##
"	Goodland, Kans.	"	"	536	494	8	18.8	##
Kansas	Topeka, Kans.	"	"	258	103	60	16.2	19.2
El.P.Am.	Dalhart, Tex.	"	"	255	199	22	18.4	24.3
	Total -	Pine	1912	4512	3929	13	18.5	27.3
Illinois	Tiskilwa, Ill.	Gum	1912	676	538	20	18.3	24.7
Missouri	E. Des Moines, Ia.	"	"	1253	1021	18	18.2	25.0
C.R.Dak.	Ely, Ia.	"	"	1232	941	23	18.0	24.0
	Total -	Gum	1912	3161	2500	21	18.1	24.3
	Special Ties Laid Out of Face - New Line							
Missouri	Carlisle, Ia.	Oak	1912	5578	5426	3	18.9	##

- Estimated average life based on Forest Products Laboratory Curve.

- Estimated average life cannot be determined when renewals are less than ten per cent.

Sheet #1. ROCK ISLAND LINES

Special Report of Ties in Test Sections - Fall Inspection 1931.
Creosoted Ties "Rueping" Process -1908 to 1912 inclusive.

Divisions	Location	Kind of Ties	Year	No. of Ties In-serted	No. of Ties Remain-ing in Track	Per Cent Re-moved	Average Life Yrs. End 1931	Estimat-ed Aver-age Life Yrs. #
El.P.Am.	McLean, Texas.	Pine	1908	1819	489	73	17.9	21.5
Okla. So.	Chico "	"	"	710	203	71	17.9	21.6
	Total -	Pine	1908	2529	692	72	17.9	21.5
El.P.Am.	McLean Texas	Gum	1908	264	83	68	18.8	22.1
Ark. La.	Ola Ark.	R.Oak	1909	728	135	81	18.3	19.6
P.H.I.T.	Yukon Okla.	"	"	649	23	96	17.1	16.3 x
	Total -	R.Oak	1909	1377	158	88	17.7	18.8
Ark. La.	Ola Ark.	Pine	1909	1012	112	89	16.8	18.6
"	Leola "	"	"	1324	109	91	15.2	18.3
P.H.I.T.	Yukon Okla.	"	"	1586	28	98	14.7	14.6 x
Okla. So.	Okarche "	"	"	380	48	87	16.1	18.9
"	Chico Texas	"	"	2386	858	64	17.6	21.5
	Total -	Pine	1909	6688	1155	82	16.2	19.6
Ark. La.	Ola Ark.	Gum	1909	80	14	82	17.4	19.6
"	Leola "	"	"	385	65	83	15.3	19.4
P.H.I.T.	Yukon Okla.	"	"	546	152	72	19.6	20.5
Okla. So.	Okarche "	"	"	71	41	42	20.4	24.7
	Total -	Gum	1909	1082	272	74	18.0	20.4
Kansas	Topeka Kans.	R.Oak	1910	1237	581	53	18.8	22.1
Ark. La.	Ola Ark.	"	"	68	7	90	17.1	17.6
	Total -	R.Oak	1910	1305	588	55	18.7	21.6
Kansas	Topeka Kans.	Pine	1910	501	229	54	18.9	21.8
Ark. La.	Ola Ark.	"	"	430	45	89	15.4	17.8
"	Leola "	"	"	1861	97	94	13.8	16.5
P.H.I.T.	Yukon Okla.	"	"	1003	37	96	16.7	15.5 x
Okla.So.	Okarche "	"	"	749	310	58	18.2	21.4
	Total -	Pine	1910	4544	718	84	15.9	18.4
Ark. La.	Leola Ark.	Gum	1910	80	9	88	13.9	17.9
Okla. So.	Okarche Okla.	"	"	73	41	45	19.6	23.1
	Total -	Gum	1910	153	50	67	16.6	20.4
Kansas	Topeka Kans.	R.Oak	1911	864	354	59	17.4	20.2
El.P.Am.	McLean Texas	"	"	517	362	30	18.8	24.2
Ark. La.	Ola Ark.	"	"	42	11	74	17.7	18.5
P.H.I.T.	Yukon Okla.	"	"	416	14	96	14.7	14.8
Okla. So.	Okarche "	"	"	149	74	50	18.4	21.5
	Total -	R.Oak	1911	1988	815	58	17.3	20.4
Kansas	Topeka Kans.	Pine	1911	180	109	39	18.7	22.7
Ark. La.	Ola Ark.	"	"	5031	481	90	16.1	16.8
"	Leola "	"	"	277	25	91	14.2	16.6
P.H.I.T.	Yukon Okla.	"	"	1406	45	96	15.2	14.8 x
Okla. So.	Okarche "	"	"	977	324	66	16.8	19.4
"	Chico Texas	"	"	2054	1095	46	17.7	21.9
	Total -	Pine	1911	9925	2079	79	16.4	18.1
Ark. La.	Ola Ark.	Gum	1911	66	23	65	16.5	19.6
Okla. So.	Okarche Okla.	"	"	146	92	37	18.7	22.9
	Total -	Gum	1911	212	115	45	18.0	21.9
El.P.Am.	McLean Texas	R.Oak	1912	152	66	56	15.8	19.5
P.H.I.T.	Yukon Okla.	"	"	373	28	92	14.6	15.6
	Total -	R.Oak	1912	525	94	82	15.0	16.9
El.P.Am.	Dalhart Texas	Pine	1912	566	349	38	17.6	21.8
Ark. La.	Ola Ark.	"	"	614	51	91	15.1	15.8
"	Leola "	"	"	1761	252	85	13.7	16.5
P.H.I.T.	Yukon Okla.	"	"	1579	87	94	14.3	14.9
Okla. So.	Okarche "	"	"	1426	591	58	16.9	19.4
"	Chico Texas	"	"	946	520	45	17.4	20.8
	Total -	Pine	1912	6892	1850	73	15.4	17.7
Okla. So.	Okarche Okla.	Gum	1912	203	144	29	18.1	23.1

- Estimated average life based on Forest Products Laboratory Curve.
x - Average life at end of 1931 more than total estimated life.
Note: "Reuping" treated ties covered by this report were more or less damaged by railwear prior to application of tie plates.

UNION PACIFIC SYSTEM-OREGON SHORT LINE RAILROAD
HAM ETT - REVERSE - INSPECTED OCTOBER 20, 1931

Designation	Kind	Treatment	Date Put in	Number Put in	Number Removed	Cause	Approx. Yrs. Service	Percent In Track	Condition
A	Sawn Western Yellow Pine Air Seasoned	30% Creosote 20% Coal Tar, 10# Bethell Process	12-23	64	-	-	7-3/4	100	Excellent
B	Hewn Lodgepole Pine Air Seasoned	30% Creosote 20% Coal Tar, 10# Bethell Process	12-23	170	-	-	7-3/4	100	Excellent
C	Sawn Coast Fir Air Seasoned	0.5# Zinc Chloride Burnett Process	12-23	950	-	-	7-3/4	100	Fair. Badly checked. Considerable plate cutting.
D	Hewn Lodgepole Pine Air Seasoned	0.5# Zinc Chloride Burnett Process	12-23	626	-	-	7-3/4	100	Fair. Checking and plate cutting. Worse than last year. 23 burned on topside.
E	Hewn Idaho Red Fir & Tamarack Air Seasoned	0.5# Zinc Chloride Burnett Process	12-23	452	-	-	7-3/4	100	Fair. Checking and plate cutting progressing. S Irons still falling out.
F	Sawn Western Yellow Pine Air Seasoned	0.5# Zinc Chloride Burnett Process	1-24	757	-	-	7-3/4	100	Fair. Considerable checking. Progressive rail cutting.
G	Hewn Lodgepole Pine Air Seasoned	30% Creosote 7½% Coal Tar 62½% Fuel Oil 10# Bethell Process	11-23	625	-	-	8	100	Excellent. Slightly plate cut on outside of rail on inside of curve
H	Sawn Coast Fir Air Seasoned	30% Creosote 7½% Coal Tar 62½% Fuel Oil 10# Bethell Process	12-23	766	-	-	8	100	Excellent. Slightly plate cut on outside of rail on inside of curve
I	Hewn Idaho Red Fir & Tamarack Air Seasoned	30% Creosote 7½% Coal Tar 62½% Fuel Oil 10# Bethell Process	12-23	633	-	-	8	100	Excellent. Slightly plate cut on outside of rail on inside of curve.
J	Sawn White Fir & Spruce Air Seasoned	0.5# Zinc Chloride Burnett Process	12-23	782	40	Checking and Shatter	8	95	Bad. Depreciating rapidly account checking and shatter.
K	Sawn Western Yellow Pine Air Seasoned	30% Creosote 7½% Coal Tar 62½% Fuel Oil 10# Bethell Process	12-23	741	-	-	8	100	Excellent. 1 broken account large knot.
L	Sawn White Fir & Spruce Air Seasoned	30% Creosote 7½% Coal Tar 62½% Fuel Oil Bethell Process	12-23	720	-	-	8	100	Excellent

UNION PACIFIC SYSTEM - OREGON SHORT LINE RAILROAD
WELLS BRANCH - INSPECTED OCTOBER 21, 1931.

Designation	Kind	Treatment	Date put in	No. put in	No. Rem.	Cause	Av.Yrs. Service	# in Track	Condition
1	Sawn White Fir & Spruce	0.5# Zinc Chloride Burnett Process	12-24	3.197	140	Decayed	7	95	Very bad.Decaying very fast
2	Sawn West Coast Fir.Air Seasoned	8.0# Creosote Betnel Process	8-24	3,148	-	-	7-1/4	100	Excellent
3	Sawn West Coast Fir.Air Seasoned	0.5# Zinc Chloride Burnett Process	9-24	2,210	-	-	7-1/4	100	Bad.Considerable decay on underside
4	Sawn West Coast Fir.Air Seasoned	0.5# Zinc Chloride 3½# Fuel Oil Two Movement	12-24	3,171	-	-	7	100	Excellent
5	Sawn Western Yellow Pine. Air Seasoned	0.5# Zinc Chloride Burnett Process	12-24	3,186	1	Broken	7	100	Fair.Progressive checking
6	Sawn Western Yellow Pine. Air Seasoned	0.5# Zinc Chloride 3½# Fuel Oil Two Movement	1-25	3,142	-	-	6-3/4	100	Excellent
7	Sawn Idaho Red Fir.Air Seasoned	0.5# Zinc Chloride Burnett Process	7 & 8 1924	3,150	-	-	7-1/4	100	Fair.Progressive checking and rail cutting
8	Sawn Idaho Red Fir.Air Seasoned	0.5# Zinc Chloride 3½# Fuel Oil Two Movement	1-25	3,209	-	-	7	100	Good.Slight checking Some rail cutting
9	Hewn Lodgepole Pine.Air Seasoned	0.5# Zinc Chloride Burnett Process	9-24	2,538	-	-	7-1/4	100	Progressive checking and rail cutting Decay starting
10	Hewn Lodgepole Pine.Air Seasoned	0.5# Zinc Chloride 3½# Fuel Oil Two Movement	2-25	2,297	-	-	6-3/4	100	Excellent
11	Sawn Lodgepole Pine.Air Seasoned	0.5# Zinc Chloride Burnett Process	1-25	3,173	-	-	6-3/4	100	Fair.Progressive checking and rail cutting Decay progressing
12	Sawn White Fir & Spruce. Air Seasoned	0.5# Zinc Chloride 3½# Fuel Oil Two Movement	12-24	3,166	-	-	7	100	Excellent
13	Hewn Idaho Red Fir.Air Seasoned	0.5# Zinc Chloride 3½# Fuel Oil Two Movement	12-24	2,526	-	-	7	100	Good.Slightly checking and plate cutting
14	Hewn Idaho Red Fir.Air Seasoned	0.5# Zinc Chloride Burnett Process	1-25	2,562	-	-	6-3/4	100	Good.Slightly checking and rail cutting Decay starting in sap wood

UNION PACIFIC SYSTEM - OREGON SHORT LINE RAILROAD
ORCHARD-BOISE-MAIN LINE- INSPECTED OCTOBER 20, 1931.

Designation	Kind	Treatment	Date Put in	Number put in	Number Removed	Cause	Approx.Yrs. Service	Percent in Track	Condition
A	Sawn Coast Fir Air Seasoned	4# Creosote 4# Fuel Oil Lowry Process	5-24	780	-	-	7-1/2	100	Excellent
B	Sawn White Fir Air Seasoned	3.6# Creosote 8.4# Fuel Oil Lowry Process	5-24	782	-	-	7-1/2	100	Excellent. Slightly rail cut at joints
C	Sawn Western Yellow Pine Air Seasoned	0.5# Zinc Chloride ,Burnett Process	3-24	3,069	-	-	7-1/2	100	Good. Progressive rail and plate cutting. 13 broken in center; 1 broken under north rail. Cross Grain.
D	Sawn White Fir & Spruce Air Seasoned	8.6# Creosote 0.4# Fuel Oil Lowry Process	3-24	3,131	-	-	7-1/2	100	Excellent. Slightly cut at joints
E	Sawn White Fir & Spruce Air Seasoned	0.5# Zinc Chloride, Burnett Process	4-24	2,915	1	Broken	7-1/2	100	Fair Considerable checking and rail cutting.
F	Sawn Idaho Red Fir Air Seasoned	8# Creosote Lowry Process	4-24	3,081	-	-	7-1/2	100	Excellent
G	Sawn Lodgepole Pine Air Seasoned	8# Creosote Lowry Process	5-24	776	-	-	7-1/2	100	Excellent
H	Sawn Western Yellow Pine Air Seasoned	8# Creosote Lowry Process	5-24	2,579	-	-	7-1/2	100	Excellent Less plate cutting than any other block
I	Sawn Coast Fir Air Seasoned	8# Creosote Lowry Process	5-24	3,078	-	-	7-1/2	100	Excellent. 42 ties east end damaged by dragging brake rigging
J	Hewn Lodgepole Pine Air Seasoned	8# Creosote Lowry Process	5-24	2,555	-	-	7-1/2	100	Excellent
K	Hewn Lodgepole Pine Air Seasoned	0.5# Zinc Chloride, Burnett Process	5-24	2,374	-	-	7-1/2	100	Progressive checking and plate cutting. Rot in sapwood to the extent of 1-1/2" deep.
L	Sawn Lodgepole Pine Air Seasoned	0.401# Zinc Chloride , Burnett Process	6-24	767	1	Broken Center Bound	7-1/2	100	Fair. Progressive checking. Rotton on underside to the extent of 2".
M	Sawn Idaho Red Fir Air Seasoned	0.5# Zinc Chloride Burnett Process	6-24	3,145	10	Broken Center Bound	7-1/2	.999	Fair. Progressive checking and plate cutting.
N	Sawn Coast Fir Air Seasoned	0.418# Zinc Chloride Burnett Process	6-24	3,037	1	Broken	7-1/2	100	Bad. Progressive plate cutting. Badly checked.

UNION PACIFIC SYSTEM - OREGON SHORT LINE RAILROAD
DEITRICH TO SHOSHONE - MAIN LINE - INSPECTED OCTOBER 21, 1931.

Designation	Kind	Treatment	Date Put in	Number Put in	Number Removed	Cause	Approx.Yrs. Service	Percent in Track	Condition
1	Hewn Lodgepole Pine Air Seasoned	0.4# Zinc Chloride Burnett Process	1-27	780	-	-	4-3/4	100	Good Some checking and plate cutting
2	Hewn Lodgepole Pine Air Seasoned	0.5# Zinc Chloride 6 mo.Seasong 7.909# Fuel Oil	1-27	799	-	-	4-3/4	100	Excellent Slight plate cutting at Joints

Appendix C

(3) PILING USED FOR MARINE CONSTRUCTION

W. G. Atwood, Chairman, Sub-Committee; G. B. Campbell, C. C. Cook, H. R. Condon, L. H. Harper, G. R. Hopkins, H. E. Horrocks, W. H. Kirkbride, A. J. Loom, G. C. Stephenson, C. M. Taylor.

The Committee submits herewith its report on the present condition of the long time test pieces in its charge, together with such other pertinent information as has been brought to its attention. The report is submitted for information.

Tropical Timber

ANGELIQUE *(Dicorynia paraensis, Benth).* The only remaining test piece is at Panama which reports:

Balboa, C. Z. Submerged September 13, 1923. There is much marine growth on the surfaces and some destruction due to Limnoria but not much. The wood boring pholads, Martesia and Xylophaga are in the timber confined close to the surfaces. Teredo are not very abundant and are all small and confined close to the surfaces. Otherwise the timber appears very sound.

MANBARKLAK *(Lecythis ollaria, L).*

Florida East Coast Ry., Key West, Fla. Submerged August 5, 1923. Through a misunderstanding this test was abandoned after the report of last year.

Panama Canal, Balboa, C. Z. Submerged September 13, 1923. The surfaces are quite clean of marine growth and very little Limnoria attack. The end has more marine growth. The inside appears to be very sound. Teredoes are confined close to the surfaces and are small. Martesia and Xylophaga are present but apparently not very abundant.

GREENHEART *(Nectanda rodieoi, Schomb).*

Panama Canal, Balboa, C. Z. Submerged September 13, 1923. The surfaces and ends were covered with oysters and marine growth. When tapped with a hammer the wood did not appear to be badly riddled. A section 2 in. thick was cut from the end and revealed plenty of Teredoes, all small close to the surfaces and end, and in addition about 20 burrows in or near the center. These were 1/8 to 3/16 inches in diameter. A few burrowing clams (pholads), Martesia and Xylophaga were present, confined to the surfaces, Limnoria work was slight. For the time this specimen has been in test, almost 9 years, it is not severely riddled.

Balboa, C. Z. New specimen, light brown heart, submerged July 18, 1932. No marine growth and no Teredo or pholads.

Balboa, C. Z. New specimen, dark brown heart, same as above.

Balboa, C. Z. New specimen, yellow heart, same as above.

The reason for testing the three specimens above listed is set forth in a letter from H. A. White, Director, British Guiana Corp. Ltd. as follows:

"The samples were cut from three separate logs, and were selected for their various degrees of heart coloration, i.e. one is the yellow heart variety, another the light brown heart variety and the third is the dark brown heart variety. There is still a fourth variety whose heart is almost black, but this is not at all common. According to local tradition, the darker the heart the more durable the greenheart is".

GREENHEART from stock. Submerged September 26, 1931. This had much marine growth on it but was only slightly attacked by Teredo. A few holes were seen that are unmistakably those of Teredo.

TURPENTINE WOOD *(Syncarpia laurifolia).*

U. S. District Engineer, Charleston, S. C.

Two specimens submerged at Castle Pinckney, June 24, 1925 and one lost in 1929. The remaining one has been attacked on the surface and ends and is about 30% damaged.

U. S. Naval Air Station, Pensacola, Fla.

Specimen lost in hurricane of August 31, 1932.

Panama Canal, Balboa, C. Z. Two specimens submerged April 19, 1929. Considerable marine growth on surfaces. Teredo are few in number and confined close to surfaces. There appear to be quite a number of pholads. Wood in good condition otherwise. (Fig. 1).

PANAMA CANAL

Through the courtesy of Brig. Gen. Harry Burgess, Governor of the Panama Canal Zone, we are able to present the following report on the tests being carried on at Balboa:

"The annual inspection of timbers being tested for resistance against marine borers was completed by Mr. James Zetek, August 9, 1932, and he has furnished the following report:

As reported last year, practically all timbers were covered with marine growth, in some cases this growth was very dense.

The only tests that were 'closed' at this time were 1631-31, 1632-32, 1633-33, 1634-34 and 1635-35, untreated fir, yellow pine, white pine, California redwood and oak, which were installed September 26, 1931 with the end in view of learning how fast the teredo and the pholads infest untreated timbers of this sort.

ANOURA (1609-2), *(Conepia sp.)* from Dutch Guiana; 8" x 8" x 24", submerged September 13, 1923. There is much marine growth on the surfaces, and much surface destruction due to gribble. A section 3" thick was cut off of the end. The cut face was sound, no teredo nor pholads at this level. At the extreme end, however, there were 6 Martesia and 1 Xylophaga and quite a number of small teredoes, but these were all confined close to the surfaces. Except for a layer not over 1" thick, the timber is very sound.

FOENGO (1608-4), *(Parinarium campestre Aubl)*, from Dutch Guiana, 8"x8"x24", submerged September 13, 1923. There is much marine growth on the surfaces and considerable destruction due to gribble. A section 4" thick was cut from the end. The cut face is sound, no teredo nor pholads showing. Teredos were all small and confined very close to the surfaces or end. A few Martesia and Xylophaga were found close to the extreme end. Otherwise very sound.

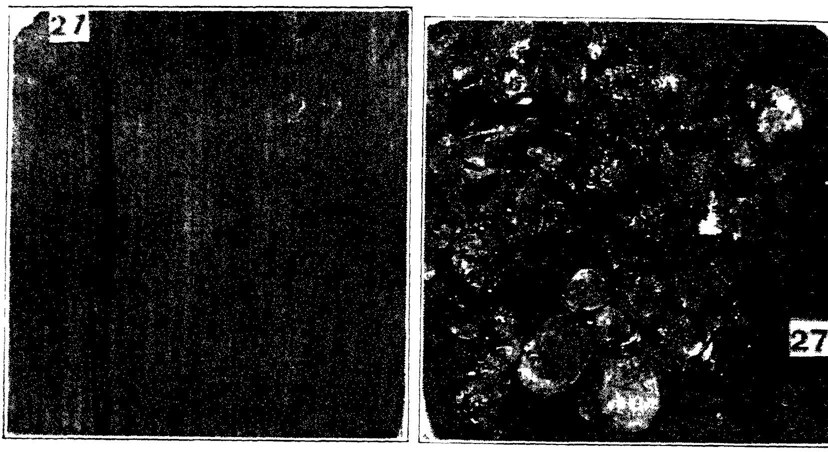


FIG. 1.—Turpentine Wood, 1621–27, 8"x8"x33" long. All heartwood. A—condition of wood 6" from end. Note almost total absence of burrows or cavities. A few teredos can be seen in upper right hand corner. B—condition of the end. Note abundance of oysters and large number of pholad openings. Careful examination will show numerous teredo holes.

SPONSE HOEDOE (1610-5), *(Licania macrophylla Bentham)*, from Dutch Guiana; 8"x8"x24", submerged September 13, 1923. The surfaces are clean, almost no marine growth, and what little there is was a sponge. Some oysters are attached to the end. Gribble work negligible. Teredos not plentiful, small in size, confined close to the surfaces and end. A section 3" thick was cut off of end. The cut face showed no teredo, but had several large cavities of Martesia. The wood is hard, does not split easily and has a twisted grain in places. As a result of this twisted grain, some of the Martesia shells are deformed. In this small section were recovered 34 Martesia and 8 Xylophaga, all full grown, and large numbers of young. The largest Martesia measured 5/8" diameter x 1½" long.

INGIEBARKI (1611-6), *(Licania heteromorpha Bentham)*, from Dutch Guiana; 6½"x7"x24", submerged September 13, 1923. The sides and ends are badly riddled, much of this due to gribble. When hit with a hammer it appeared to be sound within. Surfaces had some marine growth, including sponges. Teredos present, but confined close to the surfaces and all were small. Martesia and Xylophaga present but not nearly as many as in Sponse Hoedoe.

ALAZANO (1627-8), *(Calycophyllum candidissimum Vahl., DC.)*, from Panama; heartwood; 6"x6"x30", submerged October 17, 1929. Almost no marine growth on sides and end, general appearance clean. A section 3" thick was cut from the end. The cut surface shows numerous teredo burrows and cavities occupied by pholads, the teredos even thru the center of the timber. In this section were 34 Martesia and 12 Xylophaga. The area close to the surfaces had large number of very young pholads. This wood is reputed to be teredo-resistant, but it is far from it if the present sample is a fair one. It does not seem to favor marine growth, which is a factor worth considering.

MALABAYABAS (1606-9), *(Tristania decorticata Merr.)*, from the Philippine Islands, 12"x12"x13", submerged September 13, 1923. There is much marine growth on surfaces and ends. Plenty of oysters and sponges. Teredos appear to be few, small in size and close to the surfaces. Many opening of Martesia and Xylophaga seen. No section was cut at this time.

KAJOL LARA (1615-11), *(Metrosideros sp.)*, from the Celebes; 6½"x6½"x30", submerged October 26, 1925. Very little marine growth and practically no gribble damage. Teredos appear to be few, very small, and confined close to the surfaces. A few pholad openings present. No section was cut at this time. On tapping wood sounds good.

KAJOL MALAS (1616-12), *(Parastemon urophyllus)*, from Sumatra; 6"x6"x30", submerged October 26, 1925. There is considerable marine growth on surfaces and ends, plenty of oysters, and some destruction due to gribble, but not severe. Teredos appear to be few and small, confined close to surfaces. A section 3" thick was cut from the end. The cut surface was clean and sound, no burrows or pholad cavities. In this section were found 2 Xylophaga and 1 Martesia.

KOLAKA (1637-13) from the Celebes; 6"x6"x60", submerged April 15, 1932. This is a new sample. There is considerable marine growth on surfaces and ends, including oysters. Wood is sound, showing no indications as yet of teredo or pholad.

ALCORNOQUE (1617-14), *(Dimorphandra mora B. & H.)*, heartwood, from Panama: 6"x6"x53", submerged November 22, 1927. Considerable marine growth on surfaces and ends, including oysters. A section 5" thick was cut off of end and was a surprise to me. The cut face was clean and sound, no burrows or cavities. When split up, teredos were found only in a narrow belt ¼" to ⅜" from surfaces, mostly in the end part, none penetrating inward beyond this narrow area. Only one small Xylophaga was found. Exceptionally good condition.

RED SATINWAY (1624-21) from New South Wales; 6"x6"x24", submerged April 19, 1929. Considerable marine growth on surfaces. A section 5" thick was cut from end. The cut surfaces showed numerous cavities of Martesia. Upon splitting this block, 58 specimens of Martesia were recovered. Some were very large, forming cavities ¾" diam. (large end) and 1½" long, with the exit hole on outer surface of the timber ⅛" to ¼" diameter. The wood is very hard, with twisted grain, and as a result some of the pholads are abnormal in shape. Teredo was present but always near the surfaces, never going in more than ½" or so, all small specimens. The real damage is caused by pholads.

BRUSH BOX (1625-22) from New South Wales; 6"x6"x24", submerged April 19, 1929. Considerable marine growth on surfaces and ends. Not much gribble damage. There are some opening of pholads and the teredo picture appears to be much as last year.

AMARILLO *(Chlorophora tinctorea)* treated with A.R.E.A. No. 1 Creosote (1630-30); 9½"x12½"x9 feet, one end scarfed. Submerged September 20, 1930. Some marine growth, especially oysters. Timber is in good condition and the only indication I found of Teredo was on the cut end of the scarfed portion where I found several holes 5" deep which may be due to teredo, but they were not occupied. Quite a few tiny holes were seen which are suggestive of shot hole borers, present before the timber was treated.

FIR, Untreated (1631-31) from P.C. stock. 4"x8"x24", submerged September 26, 1931. This test and the four that follow, were made to learn how fast teredos and pholads invade timbers, but unfortunately 11 months is too much time. In the fir sample, it was *completely* riddled, shot to pieces by teredo, hardly room for another animal, completely honeycombed, and the teredos were all dead. Much silt present in the wood. No pholads. CLOSED.

Yellow Pine, untreated (1632-32) from P.C. stock, 4"x8"x24", submerged September 26, 1931. This sample was almost like the preceding one (1631-31). Closed.

White Pine, untreated (1633-33) from P.C. stock, 4"x8"x24", submerged September 26, 1931. Not quite as bad as the fir or yellow pine, but thoroughly infested with teredo, many of these still alive, some quite large. No pholads. Closed.

Redwood, California (1634-34) from P.C. stock, 4"x8"x24", submerged September 26, 1931. There were fewer teredos present, but they were much larger, alive and were all thru the wood. Two species were found, one of them probably undescribed. The other is the common Neobankia zeteki Bartsch. One Xylophaga found. Closed.

Oak (1635-35) from P.C. stock, 4"x8"x24", submerged September 26, 1931. This was the worst one of the lot, thoroughly honeycombed, with all teredos dead and much mud and silt in the burrows. No pholads. Closed.

The two pholads, Martesia and Xylophaga, are a serious problem. The Martesia especially makes large cavities, the largest noted being ¾"x1½". These clams go even into the hardest woods, and it is almost unbelievable the number that are found in such woods. They enter when very tiny, and once in the timber they remain there and are not able to get out. The opening to the outside, of a mature Martesia, is ⅛ to ¼ inches. Very often only a thin section of wood separates individuals. In a well infested timber, these pholads are able to virtually destroy wood to a depth of 1½ inches at least, and when any of these clams die, others can enter the old cavity and start working further inward. It is only a question of time when the cross-section of such timbers is greatly diminished.

In the above report the identifying numbers of the specimens consist of two parts, namely, that before the dash indicating the Panama Canal test number, and that after the dash indicating the rack in which installed.

Since our last report a specimen of Kolaka from Celebes has been added to replace a specimen which was lost. This was an unfortunate occurrence as it delays the conclusion of a test of a species of wood which appears to be highly resistant to teredo attack."

CHEMICAL WARFARE SERVICE SPECIMENS

Series No. 1

These test pieces were treated by the Chemical Warfare Service in their experimental cylinder at the Edgwood Arsenal in 1924 and 1925 with the following compounds:

No. 1. 1 per cent solution of ammoniacal copper carbonate.
No. 2. 1 per cent dyphenalamine chlorarsene in creosote.
No. 3. 0.75 per cent dyphenalamine chlorarsene and 0.5 per cent phenyldichlorarsene in fuel oil.

Reports of inspections in early autumn of 1932 follow:

New York, New Haven & Hartford RR.

Warren, R. I. Submerged May, 1925. No attack.

U. S. District Engineer, Charleston, S. C.

Two sets of specimens submerged at Castle Pinckney, June 1925.

No. 1. Treatment. One specimen practically destroyed, the other heavily attacked on the surface and ends and is considered to be about 20% destroyed.

No. 2. Treatment. One specimen destroyed by Teredo and the other aside from a heavy coating of barnacles and hydroids is in good condition.

No. 3. Treatment. One specimen destroyed and the other about 40% destroyed.

U. S. Naval Air Station, Pensacola, Fla.

Two sets of specimens submerged June 25, 1925.

No. 1. Treatment. One piece lost and the other practically destroyed by limnoria and teredo.

No. 2. Treatment. Both pieces sound.

No. 3. Treatment. Both pieces practically destroyed by limnoria and teredo.

Bureau of Lighthouses, San Juan, P. R.

Two sets of specimens submerged July 1, 1925.

No. 1. Treatment. Both pieces heavily attacked but apparently not much worse than in 1931.

No. 2. Treatment. Both pieces sound.
No. 3. Treatment. Both pieces destroyed and previously so reported.

U. S. Navy–Fleet Air Base, Coco Solo, C. Z.

No. 1. Treatment. 25% to 30% destroyed by teredo and limnoria principally limnoria.
No. 2. Treatment. Very light attack by teredo and limnoria.
No. 3. Treatment. Most heavily attacked of any of the three specimens.

Southern Pacific Co., Oakland Pier.

No. 1. Treatment. Light general limnoria attack, one small teredo found.
No. 2. Treatment. No attack.
No. 3. Treatment. No attack.
Control piece heavily attacked by limnoria and less heavily by teredo and Bankia.

Peralta St. Slip, Oakland.

No. 1. Treatment. Light limnoria attack, none this year.
No. 2. Treatment. A few limnoria around one spot.
No. 3. Treatment. Light limnoria attack on ends and localized attack on sides.

Puget Sound Navy Yard.

No. 1. Treatment. On pier 4, submerged October 1925—piece sound. On pier 8, submerged November 1925—light limnoria attack on ends.

No. 2. Treatment. On pier 4, submerged October 1925 and pier 8, submerged November 1925—no sign of attack.

No. 3. Treatment. Pier 4 specimen attacked by both limnoria and Bankia. Test closed. Pier 8 specimen is slightly attacked by limnoria but there was no indication of Bankia attack found.

Pearl Harbor Navy Yard.

Test specimens lost.

CHEMICAL WARFARE SERVICE

Series No. 2

These specimens were treated at the Edgewood Arsenal in 1931 with the following materials:

A A.R.E.A. No. 1 Creosote.
B A.R.E.A. No. 1 Creosote with 0.71 per cent methylarsenious oxide.
C A.R.E.A. No. 1 Creosote with 0.77 per cent diphenylamine chlorarsene.
D A.R.E.A. No. 1 Creosote with 2.5 per cent dinitrophenol.
E Petroleum residium with 2.5 per cent dinitrophenol.
F Petroleum residium with 0.84 per cent methylarsenious oxide.
G Petroleum residium with 0.87 per cent diphenylamine chlorarsene.

Inspection reports follow:

"A" Treatments:

Fort Tilden, N. Y. Submerged September 29, 1931. No attack.
Castle Pinckney, S. C. Submerged September 19, 1931. No attack.
Naval Air Sta., Pensacola, Fla. Submerged August 19, 1931. One specimen intact and one slightly attacked by limnoria.
Balboa, C. Z. Submerged August 25, 1931. No attack.
Bureau of Lighthouses, San Juan, P. R. Submerged August 27, 1931. No attack.
Southern Pacific Co., Oakland Pier. Submerged February 24, 1932. No attack.
Peralta St. Slip, Oakland. Submerged February 24, 1932. A few limnoria around a knot.
Puget Sound Navy Yard. Submerged November 1931. No attack.
Pearl Harbor Navy Yard. Submerged January 28, 1932. No attack on one piece, very slight limnoria attack on the other.
Cavite Naval Station. Submerged January 7, 1932. No attack.

"B" Treatments:

Fort Tilden, N. Y. No attack.
Castle Pinckney, S. C. No attack.
Pensacola, Fla. Slight limnoria attack on ends.
Balboa, C. Z. No attack.
San Juan, P. R. No attack.
Oakland Pier. No attack.
Peralta St. Slip, Oakland. Light scattered limnoria attack on sides and ends.
Puget Sound Navy Yard. No attack.
Pearl Harbor, H. I. One piece sound, one slightly attack by crustaceans.
Cavite, P. I. No attack.

"C" Treatments:

Fort Tilden, N. Y. No attack.
Castle Pinckney, S. C. No attack.
Pensacola, Fla. Slight limnoria attack on ends.
Balboa, C. Z. No attack.
San Juan, P. R. No attack.
Oakland Pier. No attack.
Peralta St. Slip, Oakland. No attack.
Puget Sound Navy Yard. One specimen sound, the other with very slight limnoria erosion on end.
Pearl Harbor, H. I. One piece sound, the other has slight crustacean attack on one side.
Cavite, P. I. No attack.

"D" Treatments:

Fort Tilden, N. Y. One specimen not attacked, the other shows slight limnoria attack on one end.
Castle Pinckney, S. C. No attack.
Pensacola, Fla. No attack.
Balboa, C. Z. No attack.
San Juan, P. R. No attack.
Oakland Pier. No attack.
Peralta St. Slip, Oakland. No attack.
Puget Sound Navy Yard. No attack.
Pearl Harbor, H. I. No attack.
Cavite, P. I. No attack.

"E" Treatments:

Fort Tilden, N. Y. Unusually heavy barnacle deposit. No attack.
Castle Pinckney, S. C. Slight limnoria attack.
Pensacola, Fla. One piece shows heavy attack by limnoria and some teredo and Martesia, about as heavily attacked as untreated control. Attack on the other specimen not quite so heavy.
Balboa, C. Z. Some attack by Martesia, no definite signs of teredo.
San Juan, P. R. One piece sound, the other lightly attacked by limnoria.
Oakland Pier. No attack.
Peralta St. Slip, Oakland. Very light scattered limnoria attack.
Puget Sound Navy Yard. One piece fairly heavily attacked by Bankia, the other riddled. (Fig. 2).
Pearl Harbor, H. I. One piece intact, the other has 8 holes in it, probably Martesia.
Cavite, P. I. No attack reported.

"F" Treatments:

Fort Tilden, N. Y. One piece with light limnoria attack on end, the other sound.
Castle Pinckney, S. C. Both pieces slightly attack by limnoria.
Pensacola, Fla. Heavy limnoria attack with a few teredo. Condition about the same as untreated control.
Balboa, C. Z. No attack.
San Juan, P. R. No attack.
Oakland Pier. Very light limnoria attack.
Peralta St. Slip. Very light scattered limnoria attack.

Puget Sound Navy Yard. Both pieces heavily attacked by limnoria and Bankia. Test closed.

Pearl Harbor, H. I. One piece sound, the other very lightly attacked by limnoria.

Cavite, P. I. The specimens not submerged until short time before inspection.

"G" Treatments:

Fort Tilden, N. Y. One piece slightly attacked by limnoria, the other not attacked.

Castle Pinckney, S. C. No attack.

Pensacola, Fla. Very heavy limnoria attack with some teredo and Martesia.

Balboa, C. Z. No attack.

San Juan, P. R. Heavy attack by limnoria.

Oakland Pier. Very light limnoria attack.

Peralta St. Slip, Oakland. Very light scattered limnoria attack.

Puget Sound Navy Yard. One piece shows light limnoria attack and the other no attack.

Pearl Harbor, H. I. No attack.

Cavite, P. I. Time of submersion too short.

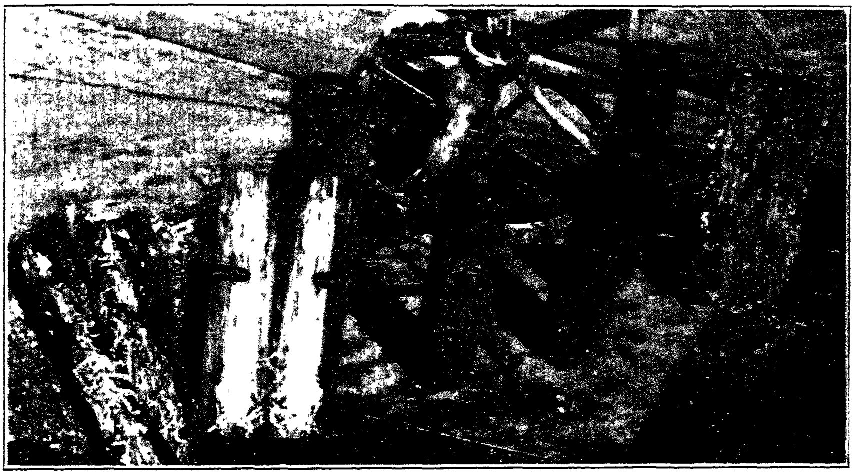


Fig. 2.—"504-32" Puget Sound Navy Yard, Bremerton, Washington, Sept. 19, 1932 Marine Piling Investigation—Pier 4 test pieces. No. A5, B5, C5 and D5 attached to ring. E5 split and at extreme left; F5 split and in left center; control piece split and at right.

Copper Resinate Tests

These specimens were treated and distributed by the patentee of the process which is a double impregnation one, and one which was reported to have given good results at Brunswick, Ga. Inspection reports follow:

Castle Pinckney, S. C. Submerged July, 1930. Both specimens attacked, one is considered to be 25 per cent and the other 20 per cent destroyed.

Pensacola, Fla. Submerged July 20, 1930. One piece lost, the other very heavily attacked by limnoria and teredo. Test closed.

Air Station, Coco Solo, C. Z. No report.

Oakland, Calif. Heavy attack by limnoria, teredo and Bankia.

Puget Sound Navy Yard. Submerged September 1930. Ends heavily attacked by limnoria and teredo.

Pearl Harbor, H. I. Both test pieces show heavy limnoria and teredo attack.

CREOSOTE TESTS

Report on the inspection of the test pieces treated with various creosotes follows:

REPORT OF INSPECTION SEPTEMBER 30 TO OCTOBER 8, 1932 OF SPECIMENS FURNISHED THROUGH DR. HERMANN VON SCHRENK AND COL. WM. G. ATWOOD AND INSTALLED IN SAN FRANCISCO BAY AREA

(P = Pine F = Fir)

Barrett Manufacturing Company Material

Placed Station B, Pier 7, San Francisco, January 1923. Moved to Biological Station, Oakland Pier, % S.P. Co., December 1925. These specimens still show no attack except lightly Limnoria.

Gate No.	*Specimen No.*	*Treatment*	*Condition September 30, 1932*
B–4	P–1	Coke Oven Original Oil	P–1 No attack.
	2	ditto Solids Removed	P–2–3 Slightly eroded by Limnoria on ends; sides slightly attacked near ends. No sign of fresh attack during year.
	3	ditto Acids Removed	
	4	ditto Bases Removed	P–4 Early attacks same as P–2–3. Very light Limnoria attack since last year.
B–5	P–5	Coke, Minus Residue 360 deg. C.	P–5–6–7 Slightly eroded by Limnoria on ends; P–5 also on sides next to ends.
	6	Coke, Minus Fraction 230–270 deg. C.	
	7	Coke, Minus Fraction up to 230 deg. C.	
	8	Coke, Minus Fraction 270–360 deg. C.	P–8 Attack previous years somewhat greater; light attack sides and ends. P–5–6–7–8 No attack during past year.
B–6	P–9	Vertical Retort Orig. Oil	P–9–10–11–12 Light general Limnoria attack on ends and sides. Little change during two previous years. Very light general Limnoria attack during last year.
	10	ditto Minus Solids	
	11	ditto Minus Acids	
	12	ditto Minus Bases	
B–7	P–13	ditto Minus Residue Above 360 deg. C.	P–13 A few light Limnoria burrows on ends during 1931. Some slight additional attack this year.
	14	ditto Minus Fraction 230–270 deg. C.	P–14 Light attack in 1930, not now traceable; shows no attack.
	15	ditto Minus Fraction up to 230 deg. C.	P–15 No attack.
	16	ditto Minus Fraction 270–360 deg. C.	P–16 Previously had light Limnoria attack on ends and shows light Limnoria attack this year.
B–8	F–1	Coke Oven Original Oil	F–1–2–3–4 All previously slightly eroded on ends. On sides previous attack was confined to line across specimens where gate had rubbed against a submerged brace. F–1–2 No fresh attack. F–3–4 very light attack, during year.
	2	ditto Solids Removed	
	3	ditto Acids Removed	
	4	ditto Bases Removed	

Gate No.	Specimen No.	Treatment	Condition September 30, 1932
B-9	F-5	Coke, Minus Residue 360 deg. C.	All were slightly eroded on ends with only a trace on sides in previous years. F-5-8 show a very light attack this year. F-6-7 show no fresh attack.
	6	Coke, Minus Fraction 230-270 deg. C.	
	7	Coke, Minus Fraction up to 230 deg. C.	
	8	Coke, Minus Fraction 270-360 deg. C.	
B-10	F-9	Vertical Retort Original Oil	F-9-10-11-12 show light attack on ends and sides near ends from previous years. All show slight attack on ends this year but no fresh attack on sides.
	10	ditto Minus Solids	
	11	ditto Minus Acids	
	12	ditto Minus Bases	
B-11	F-13	ditto Minus Residue Above 360 deg. C.	F-13-16 Considerable Limnoria attack at earlier date with little change in 1931 and very light attack this year.
	14	ditto Minus Fraction 230-270 deg. C.	
	15	ditto Minus Fraction up to 230 deg. C.	F-14-15 Light Limnoria attack in previous years with small change in 1930 and 1931. Very light attack evident this year.
	16	ditto Minus Fraction 270-360 deg. C.	

Copper and Monel Sheathing

Sheathing of piles is known to be an effective method of protection but reports to the Committee on Marine Piling Investigations, National Research Council indicated no agreement as to the probable life of various materials of which copper was one of the most important. Arrangements were therefore made for a comparative test of copper and monel metal by sheathing piles with these two materials.

The copper sheets were furnished by the Copper and Brass Research Association and the monel by the International Nickel Company. The piles were sheathed by the Bureau of Lighthouses and installed at Key West, Fla., and at the Cat Island Light in the Gulf of Mexico in the early summer of 1923.

Inspection reports from the Superintendent of Lighthouses at Key West and New Orleans follow:

Key West, Florida

"1. In compliance with your request of June 7, 1932, the test piles at the Key West Depot sheathed with copper and monel metal were inspected at low tide this afternoon. Both piles are in very good condition and from an examination with waterglass the lower portion of the sheathing of each is still below the mud line, with pile untouched by marine borers. The metal above water is covered with coating of corrosion. When marine growth was removed from portion under water metal appears as bright as new on the monel metal, and a dark brown color on the copper.

2. According to our records, these piles were installed on May 23, 1923, and have been in the water over 9 years. For this period in these waters these piles are in excellent condition."

New Orleans, La.

"1. Referring to your letter of June 7th, you are advised that inspection was made of the creosoted 6" x 6" piles in the wharf at Cat Island Lighthouse a few days ago.

2. The creosoted piles which had not been encased with sheet copper and monel metal some years ago for experimental purposes have been attacked by marine borers and the piles were encased with reinforced concrete to protect them from further attacks, also to strengthen them in order to prolong the life of the piles.

3. At the same time the unsheathed piles were encased in concrete the keeper encased those which were sheathed with monel and copper in order to further protect them

against the attack of marine borers. All the piles except two are now encased in concrete from below the bottom to about a foot above mean high water, therefore it was not practicable at the recent inspection to make any examination of the condition of the monel metal and copper at the water line. It can be stated, however, that both metals above the concrete appeared in good condition with slightly more barnacle spots on the monel metal than were on the copper.

4. There are two piles at the boat landing which were encased in copper which have not yet had the concrete casing placed around them but this will be performed by the keeper in a few days. The condition of the copper was noted and it was found that there were a number of small holes in the copper ranging in size from pin holes to 1/8" diameter. These holes were located from about the water line to about 6" below the water line and in order to protect piles from attack of marine borers these piles will be encased in concrete.

5. From the foregoing it will be seen that no future reports can be made on the comparison of monel metal and copper as these metal sheathings can no longer be observed at the water line due to the casing of concrete. The keeper recently stated that he noted that there was hardly any difference in the condition of the monel metal and the copper when he placed the concrete as both metals seemed to have a number of holes, mostly pin holes, from the water line to five or six inches below same."

Creosoted Piles at Cavite

Photographs (Fig. 3) were submitted to the Committee from the Cavite Naval Station showing sections of piles driven at the Fuel Depot, Sanghly Pt., P. I. in May 1926 and pulled Aug. 16, 1932. These piles were fir treated with 12 lb. of creosote. The attack seems to be wholly by Martesia, which is known not to be inhibited by creosote, but no limnoria or teredo attack is evident so far, although these animals are very active in practically all Phillipine harbors.

Fig. 3.—Navy Yard, Cavite, P.I. Section of creosoted pile cut in quarters after six years and three months immersion. Section cut between tide levels showing attack by Martesia Striata. 194-32 Aug. 19, 1932.

"SEA ACTION COMMITTEE"

Institution of Civil Engineers—England

The Twelfth Interim Report has been received.

The Committee exposed some pine blocks treated with 0.3 per cent or less of chlorodihydrophenarsazine (D.M.) in creosote and up to 5.3 per cent of carbazole in creosote. A set of specimens submerged at Colombo, Ceylon for 5 years were examined. No difference could be noticed between the blocks treated with creosote and creosote and D.M. Carbazole appeared to be attractive to limnoria.

In an effort to determine the relative value of the various arsenicals recommended as a result of laboratory experiments, in which very similar results were obtained in England and the United States, the British Committee treated a large number of test pieces with these poisons dissolved in alcohol. After the alcohol evaporated the toxics would show their value uninfluenced by any toxic value of the carrier. The 12th Interim report gives the result of the examination of blocks submerged at Colombo, Ceylon. The previous results were confirmed showing the superiority of D.M. over B.D.C. (a mixture of phenyl arsenious oxide and phenyl arsenious chloride), D.A. (diphenylchlorarsene) and D.A. oxide.

Experiments with these same toxics using a fuel oil carrier gave about the same result at Singapore.

A series of tests at Wellington, N.Z., showed white pine treated with Pintsch gas tar to be unattacked since 1925. Untreated blocks showed their resistance in the following descending order: brush box, totara, turpentine and white cedar. Brush box was not attacked for 3 years and only very slightly after 6 years.

The experiments to determine the value of naphthalene were initiated by the submergence of a large series of blocks at Kilindini (Kenya Colony) and Mauritius have not as yet yielded results.

This report also gives some progress reports on experiments with concrete.

OTHER FOREIGN REPORTS

Two reports dealing with marine borer attack and the resistance of tropical timbers have come into the hands of the Committee during the past year. They are reviewed below: The exact title of the first publication is as follows:

"Department Van Landbouw, Nijverheid en Handel in Nederlandsch-Indie"
Mededeelingen van het Boschbouwproefstation No. 25

Gegevens Betreffende een onderzoek naar Nederlandsch-Indische Houtsoorten, welke tegen den paalworm bestand zijn. Door J. W. Gonggrijp Nadere Gegevens Omtrent De Aantasting Van Nederlandsch-Indische Houtsoorten Door Paalworm en Andere in Zee—en Brakwater Levende Dieren Door A.T.J. Bianchi.
Landsdrukkerij — 1932 — Batavia

A valuable contribution to our knowledge of tropical timbers more or less resistant to teredo and other marine borers, has just been issued by the Department of Land and Commerce of the Dutch East Indies. This is a small volume of 147 pages containing two papers.

The first one by Gonggrijp, is a continuation and extension of the investigation commenced in Surinam, for the purpose of discovering new timbers resistant to marine borers. After a historical survey, the Author, acknowledging that protection by means of broad-headed nails, or creosote does not always entirely protect the wood, discusses the possibility of finding naturally resistant Tropical woods in the Dutch East Indies. He refers to the partial immunity of Greenheart and to the absolute immunity of Manbarklak. He raises the question as to whether the presence of large amounts of silica particles such as are contained in Manbarklak, may not be responsible to a certain degree, for the extraordinary resistance of this wood. In two chapters, he then discusses his examination of 814 timbers of the Dutch East Indies archipelago. 181 of these woods had silica inclusions. The names of these timbers are given. He, however, calls attention to the fact that the resistance to teredo attack is probably not alone dependent on the content of silica particles, but also on the density of the timber.

The last chapter of this paper deals with timbers of the Dutch East Indies which have been mentioned heretofore as resistant, calling attention to the fact that a considerable number of these must now be eliminated.

He then gives a considerable discussion with reference to further experiments to ascertain the degree of resistance against teredo for the purpose of stimulating the market for teredo resistant woods. The timbers which he believes may prove resistant, belong to the following genera: Angelesia, Artocarpus, Beilschmiedia, Cotylelobium, Endiandra, Eusideroxylon, Gluta, Heritiera, Intsia, Melanorrhoea, Metrosideros, Mimusops, Parastemon, Parinarium, Protium, Stereospermum, Sloetia, Tarrietia, Tectona, and Vitex.

Eighty figures show various marine borers; microphotographs of silica containing woods and test specimens showing both attack and immunity.

The second part of this volume consists of a paper by Bianchi, giving a compilation of data about the resistance of Dutch East Indies timbers against the attack of borers, from the results obtained after the completion of Mr. Gonggrijp's paper. The author tested a very considerable number of woods, not only in the Dutch East Indies but in San Francisco Bay and the Panama Canal. 82 different species are discussed in detail as to the place of exposure, the common name, latin name, in what type of construction used, etc. Among the most important woods, he mentions the following:

KAJOE NANI and LARA (Species of METROSIDEROS). This is a very heavy and strong wood, rich in silica and highly resistant against teredo. He examines samples exposed more than 40 years. He refers to freedom from attack in this type of wood in San Francisco Bay (1924 to 1931) and in the Panama Canal (1925 to 1931). This timber incidentally belongs to the same group as the Australian turpentine wood, known for many years for its high resistance against teredo attack.

RESAK DOERIAN (Cotylelobium flavum, PIERRE), gave good results in tests in West Borneo and is a promising timber for salt water piling.

TEMPINIS (Sloetia elongata Kds., family MORACEAE), the heartwood of this timber proved highly resistant on the East Coast of Sumatra.

KOLAKA (Parinarium corymbosum Miq., family ROSACEAE) with a high silica content, showed high resistance not only in the East Indies but in tests in San Francisco Bay and the Panama Canal.

KAJOE MALAS (Parastemon urophyllus DC) gave satisfactory results in tests in the Panama Canal (Report by J. Zetek of test specimens started October 26, 1925, last report August 14, 1929 "the wood is sound and shows no gribble or teredo"). The author calls attention however, that further tests will be necessary to determine the actual resistance of this timber.

The author also discusses two non-silica containing woods:

BELIAN or IRONWOOD (Eusideroxylon Zwageri, T. T. B., family LAURACEAE). A wood very extensively used for construction in salt water. While this is sometimes attacked, ironwood shows high resistance and is a wood well worth further trial.

TEROENTOEM (Lumnitzera littorea VOIGT, family COMBRETACEAE). This wood, while not immune, is attacked very slowly. A sample is referred to which, while showing some signs of attack, was still in use after 30 years of exposure.

DESTRUCTION OF TIMBER BY MARINE ORGANISMS IN THE PORT OF SYDNEY, N.S.W.

Published by the Sydney Harbor Trust

This book is a progress report on studies started in 1927 by the Sydney Harbor Trust. The organization and methods are very similar to those of the National Research Council, started in 1922 and inherited by the sub-committee when the National Research Council Committee was disbanded. The work is restricted to the vicinity of the Port of Sydney.

The present report describes the various borers found, especially one genus that seems to work most efficiently in almost fresh water, water having a salinity of from one to six parts salt.

Indications are that the intensity of attack by the teredine group is lessened in proportion to the rise in the hydrogenion concentration and the lowering of the oxygen content. This tends to confirm the results obtained in New York Harbor from a similar study of oxygen content. The report contains a chart showing the variations in temperature salinity, hydrogenion content and oxygen with a statement of borer conditions at each observing date for each of the 37 observing stations.

The chapter on "Protective Measures" begins with the following statement: "The remedies that have been tried for the protection of marine timber piles are innumerable and all have failed from the point of view of permanence". Turpentine wood while attacked in some locations seems to give the best results.

The following statement is also made: "The rate of deterioration of concrete in salt water has not been determined but there are borers in Port Jackson which attack it and although instances are not numerous their development remains a menace to the future".

This report describes the beginning of a study which promises much valuable information in the future if it is carried through as it has been started. It is being financed by government funds.

Summary

The continued resistance to serious attack of several tropical timbers under test in the Canal Zone is very interesting. Generally speaking, a timber or a treatment which is reasonably effective in the tropics will give much longer service in the temperate zone.

The tests of the experimental treatments by the Chemical Warfare Service after 7 to 8 years, seem to indicate that the 1 per cent ammoniacal copper carbonate and the fuel oil containing diphenylamine chlorarsene and phenyldichlorarsene both offer decided resistance to attack but that neither is as good as A.R.E.A. No. 1 creosote.

The copper resinate tests did not give satisfactory results since the specimens generally showed little additional resistance because of the treatment. This may possibly be because of the use of too low a concentration or imperfect treatment or both.

1932 REPORT ON TEST PILES

The following Tables, 1-A to 1-D, give the 1932 condition of four sets of Test Piles driven in 1919 and 1920 at Seattle, Tiburon in San Francisco Bay, San Pedro and San Diego. Each set originally consisted of seven piles, including the following:

3 Old Creosoted fir piles originally driven in 1890, Table 1-A
1 Old Creosoted fir pile originally driven in 1901, Table 1-B
2 New freshly creosoted fir piles originally driven 1919–20, Table 1-C
1 New untreated fir pile, originally driven 1919–20, Table 1-D

The untreated piles were destroyed in three or four years as shown in Table 1-D, leaving six piles in each set.

The set at San Diego was exposed for test by the Atchison, Topeka and Santa Fe Railway Company in their wharf No. 63, until the wharf was dismantled in 1925. After being repaired they were redriven by the Southern Pacific Company at Long Beach, California and the test continued.

It has been customary to make an annual diver inspection of the test piles which the Northern Pacific installed under its Dock No. 1 at Seattle for test purposes, but due to the fact that the inspections of recent years show these piles to be entirely free from Teredo, the diver inspection was allowed to go over, as the cost of such inspection was not considered justified this year.

Conclusion

It is recommended that this report be accepted as information.

TEST PILES—TABLE 1-A

CREOSOTED FIR PILES FROM SOUTHERN PACIFIC COMPANY OLD LONG WHARF, DOCK "A" OAKLAND. ORIGINALLY DRIVEN IN 1890. PULLED IN 1919 AND RE-DRIVEN ELSEWHERE. EXPOSED TO MARINE BORER ATTACK FORTY-TWO YEARS TO DATE

		Redriven for Test		*1932 Inspection*	
Mark	Date	Railroad	Location	Remarks	Borers
A- 6	1920	NP Ry. Co.	Seattle	Not inspected by diver in 1932.	------
A- 8	1920	NP Ry. Co.	Seattle	Not inspected by diver in 1932.	------
A-32	1920	NP Ry. Co.	Seattle	Not inspected by diver in 1932. All of above piles free from Teredo in 1931	------
A-19	1919	NWP RR Co.	Tiburon	Shows number of ⅛″ to ¼″ checks between high and low tide but no evidence of borer.	
A-28	1919	NWP RR Co.	Tiburon	Good condition, free from borers.	------
A-29	1919	NWP RR Co.	Tiburon	Good condition, free from borers.	------
A- 5	1919	SP Co.	San Pedro	Slight Limnoria attack of 1924 not now active. Pile coated with small barnacles. No other change.	------
A-20	1919	SP Co.	San Pedro	Same as above.	------
A-34	1919	SP Co.	San Pedro	Same as above.	------
A- 2	1920	AT & SF	San Diego	Pulled in 1925.	------
A- 2	1925	SP Co.	Long Beach	Holes attacked repaired in 1925. No further attack to date.	Limnoria
A- 7	1920	AT & SF	San Diego	Pulled in 1925.	
A- 7	1925	SP Co.	Long Beach	Holes of Limnoria attack in 1925 repaired. No further attack.	Limnoria
A-33	1920	AT & SF	San Diego	Pulled in 1925.	
A-33	1925	SP Co.	Long Beach	Holes of borer attack repaired in 1925. No further attack to date.	Limnoria.

TEST PILES—TABLE 1-B

CREOSOTED FIR PILES FROM SOUTHERN PACIFIC COMPANY OLD LONG WHARF DOCK "E", OAKLAND. ORIGINALLY DRIVEN IN 1901. PULLED IN 1919 AND RE-DRIVEN ELSEWHERE. EXPOSED TO MARINE BORER ATTACK THIRTY-ONE YEARS TO DATE

		Redriven for Test		*1932 Inspection*	
Mark	Date	Railroad	Location	Remarks	Borers
E-46	1920	NP Ry. Co.	Seattle	Not inspected by diver in 1932. No evidence of Teredo at low tide.	Teredo
E-42	1919	NWP RR Co.	Tiburon	Shows ⅜″ check in one place between high and low tide. No new attack. Two holes repaired in 1926 where borers had entered are still in good condition except one copper plate badly eroded.	Limnoria
E-50	1920	AT & SF	San Diego	Pulled in 1925.	
E-50	1925	SP Co.	Long Beach	Light attacks in 1927, repaired. No further attacks.	Limnoria

TEST PILES—TABLE 1-D

UNTREATED FIR PILES EXPOSED TO MARINE BORER ATTACK

		driven for Test		*1932 Inspection*	
Mark	Date	Railroad	Location	Remarks	Borers
49	1920	NP Ry Co.	Seattle	Broken off at mud line, 1923	Limnoria Bankia
45	1919	NWP RR Co.	Tiburon	Broken off at mud line, 1923	Limnoria Bankia Teredo Navalis
39	1920	AT & SF	San Diego	Broken off at mud line, 1923.	Limnoria and probably Bankia.

TEST PILES—TABLE 1-C

FRESHLY CREOSOTED FIR PILES EXPOSED TO MARINE BORER ATTACK, TWELVE YEARS TO DATE

		Redriven for Test		*1932 Inspection*	
Mark	Date	Railroad	Location	Remarks	Borers
47	1920	NP Ry Co.	Seattle	No apparent attack to date. Diver inspection not made in 1932.	
48	1920	NP Ry Co.	Seattle	Old sign in check and knot near bottom. No live Teredos in 1931. Diver inspection not made in 1932.	
43	1919	NWP RR Co.	Tiburon	No attack to date.	
44	1919	NWP RR Co.	Tiburon	No attack to date.	
40	1919	SP Co.	San Pedro	No attack to date. Pile coated with small barnacles.	
41	1919	SP Co.	San Pedro	Same as No.40. No attack.	
51	1920	AT & SF	San Diego	Pulled in 1925.	
51	1925	SP Co.	Long Beach	Holes of 1925 repaired. Now shows Limnoria working at low water.	Limnoria
52	1920	AT & SF	San Diego	Pulled in 1925.	
52	1925	SP Co.	Long Beach	Holes of attack in 1925 repaired. No sign of any borers at this time.	Limnoria

Appendix D

(4) SPECIFICATIONS FOR TREATMENT OF AIR-SEASONED DOUGLAS FIR

R. S. Belcher, Chairman, Sub-Committee; F. D. Mattos, Vice-Chairman, Sub-Committee; H. R. Duncan, W. R. Goodwin, G. R. Hopkins, H. E. Horrocks, R. S. Hubley, W. H. Kirkbride, A. J. Loom, G. P. MacLaren, Clyde Osborne, L. J. Reiser, Dr. Hermann von Schrenk, C. M. Taylor.

The work your Committee has completed up to this time may be divided into three parts: A study of treated Douglas fir piling and timbers which have given long service, the methods which were used for the treating of this fir, and the penetration of preservative accomplished by these treatments; a study of the practice of perforating or incising Douglas fir ties and timbers, the improvement in penetration and absorption of preservative obtained thereby, and the effect upon the strength of the incised timber; and finally a study of the effects on quality of treatment of various manipulations of the treating cycle, using experimental treating equipment along the general lines of the treating methods now in general use.

A report of the condition of creosoted Douglas fir piling and timbers which had given ten to thirty-two years' service at the time of the inspection in the 42 bridges inspected by the Committee in 1928, together with description of the treatments given this material, appears on pages 684 to 702, Vol. 30 of the Proceedings of this Association.

Incising

As is true of some of the other woods commonly given preservative treatment, the heartwood of Douglas fir offers great resistance to the injection of preservative while the sapwood can be treated more easily. Since the natural timber contains only a thin shell of sapwood, the general treatment is difficult. Furthermore, since sawed timber may be entirely heartwood, or contain only a small amount of sapwood, it follows that sawed timber is more difficult to treat than round timber which contains the full amount of original sapwood.

This refractory quality of Douglas fir has led to the development of the principle of perforating or incising the timber mechanically as an aid to the injection of preservatives. The practice of incising Douglas fir cross-ties, switch ties and bridge ties has been extensively used for the past ten years or more and the advantages of this procedure have been conclusively demonstrated. The incisions are so made and spaced (Fig. 1) that the preservative entering the wood unites between adjacent incisions and produces a more uniform and deeper penetration than would otherwise be possible and usually less time is required for treating incised than non-incised timber. The recent studies of your Committee, therefore, have been particularly directed toward the incising of bridge timbers and the reduction in strength which may result from this processing of the timber.

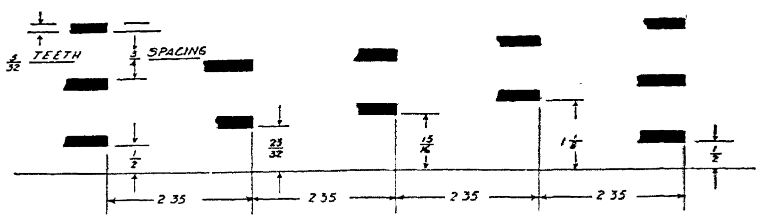


FIG. 1.—Recommended Pattern for Spacing of Teeth in Incising Machine Rolls.

Through the courtesy of E. E. Chapman, Engineer of Tests of the Santa Fe, who very kindly cooperated with your Committee, there have been made available to this Committee results of extensive tests made by Mr. Chapman to determine the effect of incising and treatment on the strength of 7×16–15 Douglas fir stringers, and at the same time the comparative strength of boxed heart and side-cut stringers. The 15-foot lengths were cut from 30-foot sticks, one-half treated and the other left untreated, so that comparisons of any group treated may be made with a like group untreated. One hundred and sixty of the 15-foot lengths were used in the test. Half of these were side-cut stringers and half boxed heart. Half of the side-cut and half of the boxed heart were incised. The incising machine used was equipped with oyster knife teeth, which penetrated the timber ¾ in. All test pieces were first air-seasoned at the National City, California, Treating Plant of the Santa Fe seven to eight months. As the National City Plant did not at that time have an incising machine large enough to take pieces of this size, the West Coast Wood Preserving Company very kindly incised the test pieces in their large incising machine at their Eagle Harbor, Washington, plant, and the McCormick Steamship Company furnished transportation to and from Eagle Harbor. This cooperation is greatly appreciated.

After treatment at National City all test specimens were shipped to the Laboratory of Tests at Topeka. The preservative treatments given the test specimens were as follows:

Non-Incised Stringers—Preservative Used A.R.E.A. Grade One Creosote

Initial vacuum, 1 hr.
Heating bath, time 5 hr., temperature at start 166°F., temperature at finish 178°F.
Maximum pressure raised over a period of 1 hr. 30 min. and maintained 15 hr.
Temperature at start of pressure period 178°F., temperature at end of pressure period 178°F.
Final vacuum, 1 hr.
Total time to treat charge, 24 hr.
Average absorption of preservative 8.78 lb. per cu. ft. of timber.

Non-Incised Stringers—Preservative Used Mixture of 45 Percent A.R.E.A. Grade One Creosote and 55 Percent Petroleum Residuum Oil

Treatment the same as above except slight variations in temperatures.
Average absorption of preservative 5.58 lb. per cu. ft. of timber.

Incised Stringers—Preservative Used A.R.E.A. Grade One Creosote

Initial vacuum, 1 hr.
Maximum pressure raised over a period of 1 hr. 30 min. and maintained 10 hr.
Temperature at start of pressure period 180°F., temperature at end of pressure period 180°F.
Final vacuum, 1 hr.
Total time to treat charge, 14 hr. 10 min.
Average absorption of preservative 9.36 lb. per cu. ft. of timber.

Incised Stringers—Preservative Used Mixture of 45 Percent A.R.E.A. Grade One Creosote and 55 Percent Petroleum Residuum Oil

Treatment same as above except slight variations in temperatures.
Average absorption of preservative 7.76 lb. per cu. ft. of timber.

Strength Tests

From Mr. Chapman's detailed and complete report of strength tests, the following excerpts have been made which it is thought are of particular interest and serve, in part, as the basis of the conclusions of this Committee pertaining to the practice of incising bridge timbers.

Test specimens were identified during the test as follows:

No. of Samples	*Identification*	*Explanation of Symbol*
20	1–20 B	Boxed heart
10	1–10 BC	Boxed heart creosoted
10	11–20 BM	Boxed heart mixture treatment
20	1–20 BP	Boxed heart incised
10	1–10 BPC	Boxed heart incised creosoted
10	11–20 BPM	Boxed heart incised mixture treatment
20	1–20 E	Side-cut
10	1–10 EC	Side-cut creosoted
10	11–20 EM	Side-cut mixture treatment
20	1–20 EP	Side-cut incised
10	1–10 EPC	Side-cut incised creosoted
10	11–20 EPM	Side-cut incised mixture treated

Transverse Tests.—Transverse tests were made on each specimen. The specimens were supported on two "I" beams, placed on the table of a 600,000-lb. Olson testing machine. Rocking knife edges were placed between the specimen and I-beam to permit free movement of the specimen. The load was applied at third points by two knife edge bearings on steel plates six inches wide. Rollers were placed between the top plates to allow movement in a horizontal plane. This set-up is shown in Fig. 2.

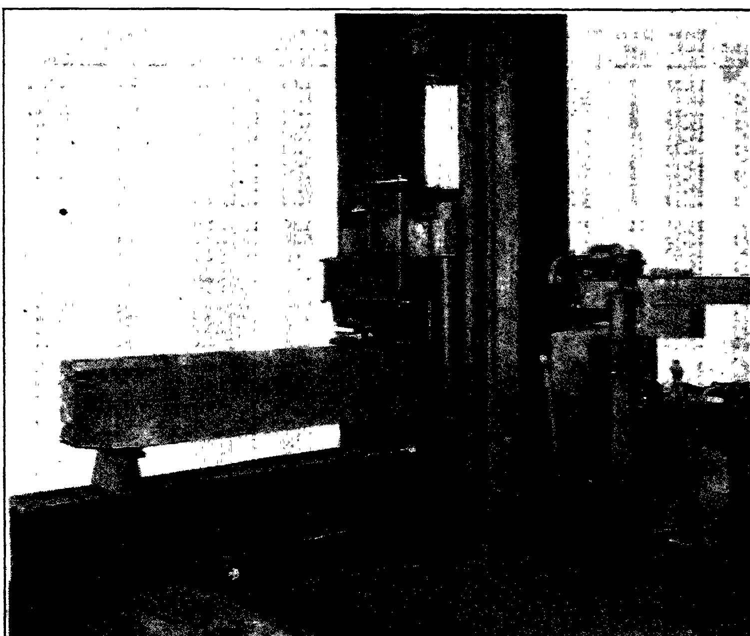


Fig. 2.—Transverse Test Specimen in Test Machine.

RESULTS OF TRANSVERSE TESTS - BOXED HEART NON-INCISED STRINGERS

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Pounds per sq. in. Elastic limit	Pounds per sq. in. Modulus of rupture	Deflection in. at Elastic limit	Deflection in. at Maximum load	Pounds per square inch Modulus of elasticity	Pounds per square inch Longitudinal shear	Type of Failure
1 B	11.90	7	30.2	2855	4110	0.55	2.90	1,645,000	315	H. S.
1 BC	15.18	7	35.3	4020	4440	0.79	0.92	1,600,000	343	H. S.
2 B	11.54	8	31.2	4270	5140	0.76	1.10	1,768,000	395	H. S.
2 BC	15.62	7	45.8	4062	4580	0.75	0.96	1,685,000	350	H. S.
3 B	13.34	12	35.3	5340	6020	0.90	1.12	1,898,000	467	H. S.
3 BC	14.80	13	46.9	5410	5920	0.74	0.86	2,328,000	458	H. S.
4 B	14.00	8	35.1	5790	5980	1.02	1.12	1,798,000	466	L. S. & C.G.T.
4 BC	16.40	9	41.2	4660	5420	0.85	1.04	1,807,000	418	H. S.
5 B	13.56	10	31.2	4530	5715	0.86	1.74	1,680,000	443	H. S.
5 BC	17.76	9	34.8	4950	5530	0.92	1.16	1,683,000	424	H. S.
6 B	14.08	8	33.6	4132	4240	0.70	3.28	1,870,000	330	H. S.
6 BC	20.20	8	44.4	4400	5760	0.80	1.22	1,712,000	441	H. S.
7 B	13.14	9	30.2	4890	5792	1.10	1.96	1,415,000	409	C.G.T.
7 BC	15.02	9	37.8	4910	5370	0.92	1.08	1,670,000	411	H. S.
8 B	12.34	9	38.4	5340	5410	0.82	0.88	2,075,000	419	H. S.
8 BC	19.38	8	52.2	5350	6280	0.82	1.06	2,030,000	480	H. S.
9 B	13.44	9	31.2	4590	6000	0.88	1.40	1,763,000	465	H. S. & C.G.T.
9 BC	13.90	10	41.2	4930	5960	0.88	1.28	1,780,000	461	H. S.
10 B	13.10	10	34.2	4050	4903	0.62	0.90	2,105,000	385	H. S.
10 BC	15.60	7	39.7	4250	4250	0.66	0.66	2,030,000	320	H. S.
11 B	13.90	16	35.5	5295	5510	0.80	0.98	2,115,000	427	H. S.
11 BM	14.44	14	37.4	4890	5400	0.81	0.98	1,923,000	421	H. S.
12 B	13.84	7	31.3	4490	5000	0.88	1.08	1,620,000	389	H. S.
12 BM	12.60	9	32.6	5460	5530	1.04	1.06	1,665,000	430	H. S.
13 B	12.66	9	37.0	5395	6345	0.90	1.28	1,913,000	493	H. S.
13 BM	12.98	12	41.5	4380	5410	0.87	1.18	1,605,000	419	C.G.T.
14 B	14.98	7	30.1	4925	4925	0.92	0.92	1,700,000	383	C.G.T. & H. S.
14 BM	14.60	6	33.3	4090	4782	0.78	1.15	1,835,000	371	H. S.
15 B	14.14	8	32.6	4445	4580	0.78	0.84	1,815,000	356	H. S.
15 BM	13.38	8	33.7	4058	4540	0.78	0.92	1,660,000	350	H. S.
16 B	10.86	8	31.1	4870	5340	0.88	0.89	2,285,000	415	H. S.
16 BM	15.24	9	45.8	4640	5345	0.86	1.04	1,783,000	415	H. S. & C.G.T.
17 B	15.20	6	34.2	5685	6065	1.12	1.30	1,612,000	471	H. S.
17 BM	15.82	6	40.2	5680	5980	0.88	1.16	2,050,000	464	H. S. & C.G.T.
18 B	16.40	8	30.5	4250	4250	0.84	0.84	1,610,000	329	L. S. & C.G.T.
18 BM	14.88	8	33.5	3990	4685	0.84	1.14	1,510,000	364	H. S.
19 B	15.30	11	31.4	5000	6020	1.10	1.62	1,452,000	404	H. S. & C.G.T
19 BM	14.90	9	35.0	4450	5610	1.00	1.52	1,418,000	450	C. G. T.
20 B	11.26	6	31.8	4605	5090	0.82	1.05	1,800,000	392	H. S.
20 BM	15.06	6	36.4	4415	4980	0.78	0 96	1,800 000	387	" "

NOTE: HS equals Horizontal shear.
LS equals Longitudinal shear.
CGT equals Cross Grain Tension.

RESULTS OF TRANSVERSE TESTS - BOXED HEART INCISED STRINGERS

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Pounds per sq. in. Elastic limit	Pounds per sq. in. Modulus of rupture	Deflection in. at Elastic limit	Deflection in. at Maximum load	Pounds per square inch Modulus of elasticity	Pounds per square inch Longitudinal shear	Type of Failure
1 BP	13.22	7	33.2	4980	5050	1.00	1.06	1,598,000	388	C.G.S.
1 BPC	16.10	5	39.8	4525	5200	0.82	1.04	1,760,000	401	H. S.
2 BP	16.94	8	32.4	4490	5500	0.85	1.15	1,685,000	424	C.G.S.
2 BPC	15.62	8	37.5	4455	5070	0.84	1.08	1,690,000	393	H. S.
3 BP	14.04	14	33.0	2770	4520	0.50	2.62	1,747,000	278	H. S.
3 BPC	14.72	13	36.4	1883	2965	0.68	2.00	875,000	238	H. S.
4 BP	13.78	5	32.3	4620	4950	0.86	0.96	1,727,000	380	H. S.
4 BPC	15.96	6	39.6	4100	5200	0.71	1.10	1,840,000	403	H. S.
5 BP	14.04	7	32.3	4090	4615	0.80	0.95	1,632,000	358	H. S.
5 BPC	15.90	8	38.4	3940	3940	0.80	0.80	1,925,000	303	H. S.
6 BP	13.94	11	33.5	4750	4750	0.79	1.06	1,635,000	370	H. S.
6 BPC	16.18	13	45.0	3575	3940	0.70	0.86	1,615,000	306	H. S.
7 BP	14.80	8	30.1	4490	5090	0.94	1.12	1,525,000	392	H. S. & C.G.T.
7 BPC	14.72	10	39.6	4450	5130	0.99	1.26	1,433,000	397	H. S.
8 BP	11.44	8	31.9	1910	3565	0.37	2.65	1,635,000	279	H. S.
8 BPC	15.36	8	39.7	4920	5175	0.94	1.04	1,670,000	398	H. S.
9 BP	11.60	8	37.4	5425	5640	0.76	0.84	2,290,000	436	H. S.
9 BPC	16.42	10	45.6	4500	5740	0.76	1.20	1,885,000	442	H. S.
10 BP	12.90	6	34.4	4985	5540	0.90	1.02	1,765,000	418	H. S.
10 BPC	15.70	6	40.3	4490	5080	0.78	1.04	1,836,000	392	H. S.
11 BP	13.62	8	32.1	5030	5690	1.02	1.35	1,587,000	438	H. S.
11 BPM	15.88	9	35.3	5000	5290	0.98	1.18	1,630,000	408	H. S.
12 BP	12.68	9	27.8	4135	4870	0.68	1.00	1,915,000	373	H. S.
12 BPM	14.82	8	35.1	4525	4760	0.92	1.00	1,570,000	368	H. S. & C.G.T.
13 BP	14.52	7	31.8	4090	5020	0.79	1.25	1,650,000	388	H. S.
13 BPM	14.94	5	38.1	4025	4205	0.84	0.90	1,525,000	325	H. S.
14 BP	15.60	6	30.7	4050	4425	0.76	0.90	1,705,000	342	H. S.
14 BPM	15.32	6	38.0	3880	3880	0.74	0.74	1,670,000	298	H. S.
15 BP	11.62	11	33.2	4950	5025	1.00	1.06	1,588,000	387	H. S.
15 BPM	15.24	11	41.5	5300	5625	1.00	1.10	1,690,000	435	H. S.
16 BP	15.60	9	32.0	5010	5240	0.90	1.20	1,775,000	405	H. S.
16 BPM	16.52	8	41.4	4570	5200	0.73	0.96	1,995,000	400	H. S.
17 BP	13.52	9	32.2	4600	5860	0.74	1.16	2,015,000	454	H. S.
17 BPM	12.90	8	38.9	5330	5560	0.82	0.90	2,063,000	428	H. S.
18 BP	12.96	9	32.0	4018	4220	0.74	0.90	1,730,000	327	H. S.
18 BPM	15.54	8	36.6	4050	4735	0.79	1.06	1,622,000	364	H. S.
19 BP	14.00	7	33.0	4475	5125	0.84	1.20	1,705,000	395	H. S.
19 BPM	16.06	7	41.6	4480	5480	0.74	1.14	1,930,000	422	H. S.
20 BP	11.42	6	33.0	4565	5340	0.72	1.04	2,028,000	411	H. S.
20 BPM	15.22	7	38.2	4450	4725	0.80	0.96	1,790,000	367	H. S.

NOTE: CGS equals Cross grain shear.
HS equals Horizontal shear.
CGT equals Cross grain tension.

RESULTS OF TRANSVERSE TESTS - SIDE-CUT NON-INCISED STRINGERS

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Pounds per sq. in. Elastic limit	Pounds per sq. in. Modulus of rupture	Deflection in. at Elastic limit	Deflection in. at Maximum load	Pounds per square inch Modulus of elasticity	Pounds per square inch Longitudinal shear	Type of failure
1 E	13.60	8	35.5	5450	6100	0.88	1.12	1,973,000	472	H. S.
1 EC	14.78	11	41.0	4842	5475	0.81	0.99	1,892,000	418	H. S.
2 E	14.70	7	36.1	6160	6180	1.02	1.02	1,935,000	478	H. S.
2 EC	15.34	7	55.3	6055	6410	1.07	1.14	1,790,000	498	H. S.
3 E	15.14	12	34.3	5560	5560	0.94	0.94	1,885,000	431	H. S.
3 EC	15.04	11	40.8	4385	5405	0.77	1.34	1,813,000	425	H. S.*
4 E	13.82	12	36.3	5015	5120	0.86	4.50	1,850,000	498	H. S. & C.G.T.
4 EC	19.94	9	42.7	5305	5530	0.86	0.94	1,955,000	440	H. S.
5 E	10.08	9	26.0	4480	4890	0.82	1.18	1,750,000	378	C.G.T.
5 EC	16.34	7	42.6	4840	5510	0.84	1.12	1,825,000	428	H. S.
6 E	15.76	10	33.0	4560	5009	0.78	0.94	1,870,000	392	H. S.
6 EC	17.58	10	48.2	3970	5100	0.65	1.00	1,921,000	396	H. S.
7 E	13.86	7	29.9	4475	4905	1.00	1.38	1,430,000	379	H. S. & C.G.T.
7 EC	15.16	6	43.4	4035	4470	0.98	1.28	1,505,000	345	H. S.
8 E	13.46	10	34.5	5000	5470	0.86	1.06	1,855,000	422	H. S.
8 EC	16.08	8	39.4	4880	5465	0.86	1.10	1,800,000	425	H. S.
9 E	11.18	10	35.6	4915	5450	0.84	1.20	1,870,000	420	H. S.
9 EC	15.80	9	41.2	4873	5130	0.84	1.00	1,848,000	397	C.G.T.
10 E	16.80	11	38.5	5385	6420	0.86	1.48	2,000,000	495	C.G.T.
10 EC	16.82	9	49.4	5650	6840	0.90	1.42	1,985,000	531	H. S.
11 E	15.34	16	38.7	5260	6670	0.87	1.70	1,918,000	518	C.G.T.
11 EM	14.56	14	42.7	5300	6490	0.86	1.72	1,905,000	503	H. S.
12 E	13.54	12	33.6	4915	5505	0.86	1.08	1,822,000	423	H. S.
12 EM	14.64	8	44.5	4810	5070	0.77	0.98	1,763,000	394	H. S.
13 E	11.30	7	35.1	5000	5600	0.87	1.24	1,838,000	432	H. S.
13 EM	14.80	8	39.1	4060	4960	0.86	1.12	1,877,000	383	H. S.
14 E	16.52	10	44.1	4965	5182	0.78	0.86	2,030,000	400	H. S.
14 EM	16.24	10	49.9	5745	6160	0.94	1.62	1,947,000	476	H. S.
15 E	13.06	11	36.5	5200	5500	0.92	0.92	1,705,000	426	H. S.
15 EM	11.74	9	40.0	4920	5945	0.78	1.08	2,010,000	458	H. S.
16 E	12.38	15	33.3	5785	6190	1.10	1.30	1,670,000	481	H. S.
16 EM	12.36	14	37.3	5300	5630	1.00	1.12	1,690,000	436	C.G.S.
17 E	10.90	6	33.4	4485	6425	0.97	2.00	1,475,000	495	H. S.
17 EM	14.34	7	43.2	4875	5105	0.98	1.16	1,590,000	396	H. S.
18 E	8.80	12	30.2	4950	5485	0.89	1.28	1,780,000	424	H. S.
18 EM	13.36	10	36.9	4920	6150	0.90	1.52	1,705,000	471	H. S.
19 E	11.84	8	32.1	4970	6360	0.82	1.60	1,935,000	493	H. S.
19 EM	13.66	9	39.8	4875	6010	0.80	2.00	1,945,000	521	H. S.
20 E	14.88	14	36.7	5470	5470	0.86	0.86	2,030,000	423	H. S.
20 EM	13.46	13	40.6	4875	5410	0.78	0.96	1,995,000	419	H. S.

NOTE: HS equals Horizontal shear.
CGT equals Cross grain tension.
CGS equals Cross grain shear.
* equals Light cracking before failure.

RESULTS OF TRANSVERSE TESTS - SIDE-CUT INCISED STRINGERS

Specimen Number	Moisture %	Rings per. in.	Wt. per cubic foot	Pounds per sq. in. Elastic limit	Pounds per sq. in. Modulus of rupture	Deflection in. at Elastic limit	Deflection in. at Maximum load	Pounds per square inch Modulus of elasticity	Pounds per square inch Longitudinal shear	Type of failure
1 EP	15.66	10	36.8	4485	4790	0.70	0.82	2,045,000	368	H. S.
1 EPC	16.52	9	51.1	4850	5460	0.86	1.08	1,785,000	424	H. S.
2 EP	13.40	7	29.2	4200	4640	0.77	1.06	1,560,000	358	C.G.T.
2 EPC	14.94	6	39.9	4100	4405	0.90	0.96	1,450,000	342	C.G.T.
3 EP	13.52	12	38.1	2754	4540	0.50	1.54	1,745,000	349	H. S.
3 EPC	15.60	10	46.1	4925	5860	0.76	1.04	2,060,000	451	H. S.
4 EP	10.00	12	36.6	5340	5480	0.94	1.00	1,812,000	423	H. S.
4 EPC	17.60	9	47.0	4650	5360	0.82	0.98	1,875,000	411	H. S.
5 EP	14.16	7	37.6	5000	5120	0.81	0.86	1,975,000	394	H. S.
5 EPC	16.56	8	48.6	4690	5310	0.85	0.98	1,830,000	411	H. S.
6 EP	14.48	10	30.4	4520	5140	1.02	1.24	1,430,000	397	C.G.T.
6 EPC	16.78	13	42.7	4420	5320	0.89	1.36	1,568,000	413	H. S.
7 EP	13.96	15	32.6	4078	4760	0.80	1.04	1,640,000	366	H. S.
7 EPC	15.70	14	40.8	4060	5015	0.70	1.00	1,805,000	384	H. S.
8 EP	13.32	8	37.8	5340	5645	0.88	0.96	1,940,000	435	H. S.
8 EPC	17.88	10	49.3	4855	5060	0.84	0.90	1,825,000	392	H. S.
9 EP	13.76	13	32.6	4115	4120	0.79	2.10	1,670,000	317	H. S.
9 EPC	15.86	9	41.3	4970	5795	0.90	1.40	1,760,000	448	H. S.
10 EP	17.28	12	37.4	5390	6120	0.92	1.26	1,773,000	471	H. S.
10 EPC	17.04	11	45.4	4030	4735	0.82	1.18	1,565,000	366	H. S.
11 EP	12.08	13	37.6	4965	5360	0.80	0.94	1,980,000	415	H. S.
11 EPM	16.88	12	53.7	4895	5550	0.81	1.08	1,920,000	428	H. S.
12 EP	11.58	14	55.0	4620	5500	0.80	1.06	1,875,000	419	H. S.
12 EPM	14.68	14	44.6	4462	5850	0.80	1.22	1,775,000	452	H. S.
13 EP	14.26	11	34.4	4550	4880	0.85	2.66	1,725,000	373	H. S.
13 EPM	16.68	10	44.1	4422	5120	0.89	1.20	1,573,000	399	H. S.
14 EP	15.52	12	30.7	4060	5090	0.84	1.68	1,540,000	392	C.G.T.
14 EPM	16.02	13	41.2	5300	5550	0.98	1.38	1,727,000	429	H. S.
15 EP	14.18	10	34.2	4025	4550	0.72	0.98	1,780,000	353	H. S.
15 EPM	17.24	9	43.7	4455	4810	0.80	1.10	1,783,000	371	H. S.
16 EP	14.88	14	36.2	4120	4690	0.80	1.02	1,658,000	358	H. S.*
16 EPM	16.44	12	43.3	4000	4660	0.85	1.20	1,614,000	361	H. S.*
17 EP	11.58	12	32.4	4915	5270	1.04	1.24	1,508,000	407	H. S.
17 EPM	15.64	11	39.4	4025	5840	0.84	1.82	1,523,000	452	H. S.
18 EP	16.86	13	35.4	4550	5290	0.76	1.00	1,930,000	405	H. S.
18 EPM	16.76	15	41.9	4100	4440	0.73	0.86	1,785,000	343	H. S.
19 EP	13.64	11	33.5	3940	3940	0.80	0.80	1,580,000	299	H. S.
19 EPM	16.18	11	43.0	3600	3600	0.71	0.71	1,670,000	294	H. S. & C.G.T.
20 EP	17.24	8	36.4	4750	5450	0.84	1.18	1,810,000	420	H. S. & C.G.T.
20 EPM	16.32	8	43.0	5360	5940	0.88	1.06	1,940,000	457	H. S.

NOTE: HS equals Horizontal shear.
CGT equals Cross grain tension.
* equals breaking at center due to cross grain.

SUMMARY OF TRANSVERSE TEST

Specimen	Pounds per sq. in. Elastic limit	Modulus of rupture	Modulus of elasticity	Longitudinal shear	Per cent change Elastic limit	Modulus of rupture
	Effect of Treatment					
1-10 B	4611	5331	1,801,700	409		
1-10 BC	4714	5353	1,832,800	411	+2.24	+0.47
11-20 B	4896	5312	1,792,200	412		
11-20 BM	4625	5252	1,704,900	406	-5.54	-1.13
1-10 BP	4183	4922	1,725,900	372		
1-10 BPC	4084	4744	1,652,900	368	-2.37	-3.61
11-20 BP	4492	5081	1,769,800	392		
11-20 BPM	4561	4946	1,748,500	382	+1.51	-2.61
1-10 E	5102	5510	1,841,800	426		
1-10 EC	4884	5534	1,833,600	429	-4.27	-0.43
11-20 E	5130	5839	1,840,300	451		
11-20 EM	4968	5763	1,848,700	446	-3.28	-1.30
1-10 EP	4522	5035	1,759,000	388		
1-10 EPC	4595	5232	1,752,300	404	+1.61	+3.92
11-20 EP	4449	5002	1,738,600	384		
11-20 EPM	4482	5156	1,733,000	399	+0.74	+3.08
	Effect of Incision on Untreated Specimens					
1-20 B	4753	5322				
1-20 BP	4338	5002			-8.74	-6.00
1-20 E	5116	5674				
1-20 EP	4486	5018			-12.32	-11.57
	Effect of Incision on Treated Specimens					
1-10 BC	4714	5353				
1-10 BPC	4084	4744			-13.35	-11.40
11-20 BM	4625	5252				
11-20 BPM	4561	4946			-1.38	-5.82
1-10 EC	4884	5534				
1-10 EPC	4595	5232			-5.91	-5.46
11-20 EM	4968	5763				
11-20 EPM	4482	5156			-9.78	-10.52
	Comparison of Side-Cut to Boxed Heart					
1-20 B	4753	5322				
1-20 E	5116	5674			+7.63	+6.62
1-20 BP	4338	5002				
1-20 EP	4486	5018			+3.46	+0.32
1-20 BC+BM	4670	5302				
1-20 EC+EM	4926	5648			+5.48	+6.50
1-20 BPC+BPM	4322	4845				
1-20 EPC+EPM	4538	5194			+5.00	+7.20

Deflections were measured by means of a fine steel wire and scale graduated to hundredths inch. The wire was stretched along the neutral axis between nails located vertically above the knife supports. The wire was kept taut by attaching a weight to one end. Deflection readings were taken during continuous application of load.

All specimens were placed in machine in same position, as nearly as possible, with reference to grain structure. A 2000-lb. load was first applied to give a firm bearing and the scale set at zero. Readings were taken at 5000-lb. load increments. The test data are tabulated on pages 458 to 459 inclusive.

Compression Test Parallel to Grain.—Specimens for compression test parallel to the grain were cut from the transverse specimens after making the transverse tests. It was intended to make the specimens exactly 5 by 5 by 12 in., but due to lost motion in the saw, some were slightly under size.

An initial load of 2000 lb. was first applied and deflectometer set at zero. Readings were taken at increments of 5000 lb. to elastic limit. The weighing beam was then kept balanced until maximum load was reached. This set-up is shown in Fig. 3. Data are

tabulated on pages 469 to 470 inclusive. Fig. 4 is a photograph showing characteristic failures for this test.

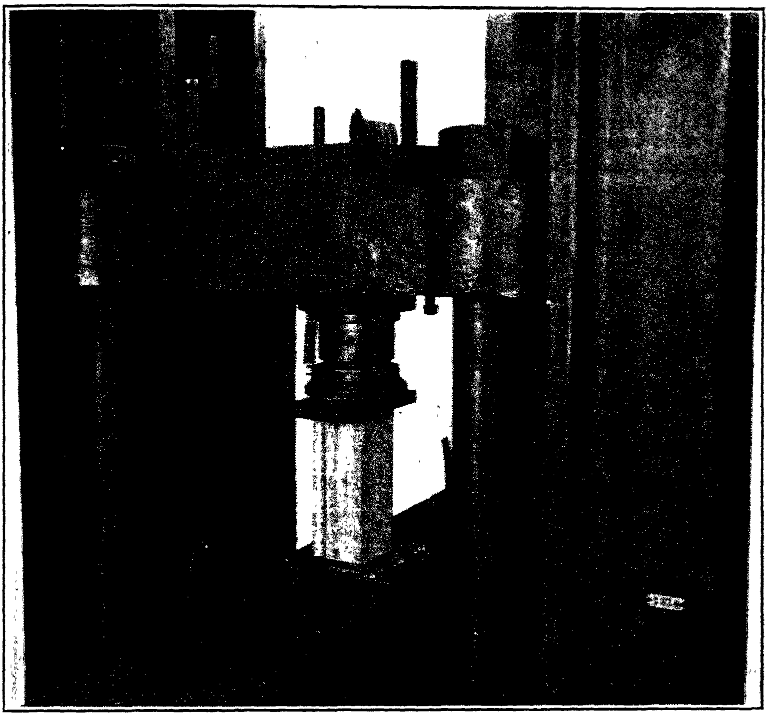


FIG. 3.—Compression Test Parallel to Grain, Specimen in Test Machine.

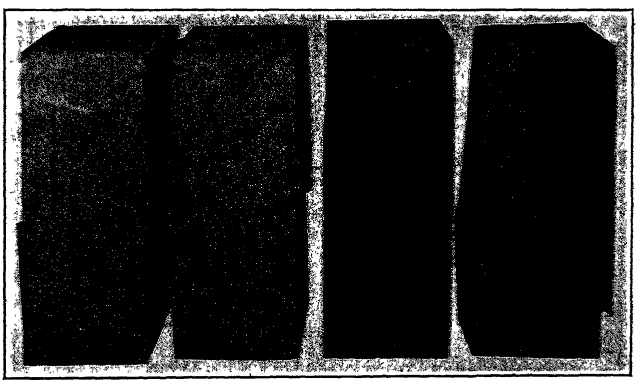


FIG. 4.—Characteristic Failure of Specimens in Compression Test Parallel to Grain.

RESULTS OF COMPRESSION TESTS PARALLEL TO GRAIN
BOXED HEART - NON-INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Lb. per sq. in. Elastic Limit	Lb. per sq. in. Max. Load	Deflection in. Elastic Limit	Deflection in. Max. Load	Modulus of Elasticity lb. per sq. in.	Type of Failure
1 B	11.90	7	30.2	6280	6480	0.112	0.134	672,800	C. & S.
1 BC	15.18	7	35.3	4514	5110	0.098	0.145	552,500	C. & S.
2 B	11.54	8	31.2	5330	5490	0.096	0.116	660,300	C. & S.
2 BC	15.62	7	45.8	6110	6550	0.087	0.126	842,500	C. & S.
3 B	13.34	12	35.3	5280	5860	0.117	0.151	541,500	C. & S.
3 BC	14.80	13	46.9	4680	4990	0.108	0.131	[illegible]20,000	C. & S.
4 B	14.00	8	35.1	5368	6248	0.096	0.143	670,500	C. & S.
4 BC	18.40	9	41.2	4904	5280	0.095	0.121	620,000	C. & S.
5 B	13.56	10	31.2	6875	7275	0.091	0.121	906,500	C. & S.
5 BC	17.76	9	34.8	5080	5410	0.106	0.146	657,500	C. & S.
6 B	14.68	8	33.6	6027	6125	0.109	0.138	664,000	C. & S.
6 BC	20.20	8	44.4	5080	5615	0.093	0.180	656,000	C. & S.
7 B	13.14	9	30.2	5359	5968	0.121	0.169	530,000	C. & S.
7 BC	15.02	9	37.8	6080	6258	0.107	0.122	762,500	C. & S.
8 B	12.34	9	38.4	6280	6800	0.137	0.194	550,000	C.& S.
8 BC	19.38	8	52.2	5628	5980	0.105	0.127	643,000	C. & S.
9 B	13.44	9	31.2	4480	4570	0.092	0.118	584,000	C. & S.
9 BC	13.90	10	41.2	5897	5897	0.121	0.121	585,000	C. & S.
10 B	13.10	10	34.2	6075	6300	0.114	0.151	639,000	C. & S.
10 BC	15.60	7	39.7	5680	5925	0.123	0.178	555,000	C. & S.
11 B	13.90	16	35.5	5280	6080	0.095	0.115	607,000	C. & S.
11 BM	14.44	14	37.4	5680	5902	0.111	0.148	614,000	C. & S.
12 B	13.84	7	31.3	4904	5405	0.116	0.151	507,400	C.&S.
12 BM	12.60	9	35.6	5067	5420	0.101	0.145	602,000	C. & S.
13 B	12.66	9	37.0	5928	6900	0.104	0.133	684,000	C. & S.
13 BM	12.98	12	41.5	5442	5862	0.098	0.124	654,000	C. & S.
14 B	14.98	7	30.1	5680	6280	0.114	0.140	697,500	C. & S.
14 BM	14.86	6	33.3	4494	5075	0.119	0.209	453,000	C. & S.
15 B	14.14	8	32.6	5280	5300	0.115	0.150	550,500	C. & S.
15 BM	13.38	8	33.7	5280	5302	0.105	0.116	603,000	C. & S.
16 B	10.86	8	31.1	5476	6450	0.102	0.130	644,000	C. & S.
16 BM	15.24	9	45.8	6563	6775	0.067	0.075	1175,400	C. & S.
17 B	15.20	6	34.2	3772	4200	0.084	0.115	536,000	C. & S.
17 BM	15.82	6	40.2	5955	6160	0.100	0.127	716,000	C. & S.
18 B	16.40	8	30.5	4280	4750	0.137	0.199	377,000	C. & S.
18 BM	14.88	8	33.5	4301	4680	0.096	0.134	537,500	C. & S.
19 B	15.30	11	31.4	4904	5306	0.109	0.129	539,800	C. & S.
19 BM	14.90	9	35.0	5002	5430	0.109	0.129	506,000	C. & S.
20 B	11.26	6	31.8	4592	5000	0.095	0.151	581,000	C. & S.
20 BM	15.06	6	36.4	4360	4750	0.085	0.097	616,000	C. & S.

NOTE: C.&S. equals Crushed and Split.

RESULTS OF COMPRESSION TESTS PARALLEL TO GRAIN
BOXED HEART - INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Lb. per sq. in. Elastic Limit	Lb. per sq. in. Max. Load	Deflection in. Elastic Limit	Deflection in. Max. Load	Modulus of Elasticity lb. per sq. in.	Type of Failure
1 BP	13.22	7	33.2	5478	5893	0.093	0.107	706,000	C. & S.
1 BPC	16.10	5	39.8	6174	6384	0.097	0.112	764,000	C. & S.
2 BP	16.94	8	32.4	5880	6080	0.124	0.133	568,000	C. & S.
2 BPC	15.62	8	37.5	5080	5410	0.093	0.120	655,500	C. & S.
3 BP	14.04	14	33.0	5893	6308	0.108	0.121	656,000	C. & S.
3 BPC	14.72	13	36.4	6304	6400	0.095	0.124	797,500	C. & S.
4 BP	13.78	5	32.3	4536	4760	0.090	0.114	604,000	C. & S.
4 BPC	15.96	6	39.6	4112	4560	0.079	0.117	625,000	C. & S.
5 BP	14.04	7	32.3	5890	6450	0.107	0.128	660,500	C. & S.
5 BPC	15.90	8	38.4	4100	4700	0.091	0.133	541,500	C. & S.
6 BP	13.94	11	33.5	5413	5610	0.123	0.143	528,000	C. & S.
6 BPC	16.18	13	45.0	5280	5460	0.102	0.137	516,000	C. & S.
7 BP	14.80	8	30.1	4953	5370	0.087	0.141	684,000	C. & S.
7 BPC	14.72	10	39.6	4280	4880	0.093	0.130	554,000	C. & S.
8 BP	11.44	8	31.9	3700	4060	0.099	0.133	449,000	C. & S.
8 BPC	15.36	8	39.7	4479	4700	0.082	0.110	655,400	C. & S.
9 BP	11.60	8	37.4	5394	5850	0.092	0.125	702,500	C. & S.
9 BPC	16.42	10	45.6	5850	6470	0.098	0.135	716,500	C. & S.
10 BP	12.90	6	34.4	5280	5340	0.082	0.099	772,500	C. & S.
10 BPC	15.70	6	40.3	4960	5290	0.093	0.129	640,000	C. & S.
11 BP	13.62	8	32.1	5412	5630	0.098	0.114	664,000	C.& S.
11 BPM	15.88	9	35.3	4514	4840	0.095	0.160	572,000	C. & S.
12 BP	12.68	9	27.8	5359	5625	0.088	0.119	730,000	C. & S.
12 BPM	14.82	8	35.1	4410	4900	0.095	0.135	557,500	C. & S.
13 BP	14.52	7	31.8	4490	4664	0.102	0.125	[illegible]27,500	C. & S.
13 BPM	14.94	5	38.1	4797	4950	0.093	0.124	617,000	C. & S.
14 BP	15.60	6	30.7	4917	5250	0.093	0.127	634,500	C. & S.
14 BPM	15.32	6	38.0	5968	6128	0.108	0.137	645,000	C. & S.
15 BP	11.62	11	33.2	5562	5950	0.124	0.158	538,000	C. & S.
15 BPM	15.24	11	41.5	4880	5200	0.114	0.168	514,000	C. & S.
16 BP	15.60	9	32.0	5680	6022	0.125	0.155	546,000	C. & S.
16 BPM	16.52	8	41.4	5510	5780	0.078	0.107	847,500	C. & S.
17 BP	13.52	9	32.2	4648	5060	0.096	0.136	579,000	C. & S.
17 BPM	12.90	8	38.9	6205	6540	0.095	0.116	786,000	C. & S.
18 BP	12.96	9	32.0	4937	5078	0.115	0.137	515,000	C. & S.
18 BPM	15.54	8	36.6	4280	4680	0.128	0.173	401,500	C. & S.
19 BP	14.00	7	33.0	5280	5360	0.114	0.137	555,700	C. & S.
19 BPM	16.06	7	41.6	4680	4720	0.119	0.134	473,000	C. & S.
20 BP	11.42	6	33.0	5357	5580	0.125	0.190	515,000	C. & S.
20 BPM	15.22	7	38.2	4480	4950	0.113	0.157	476,000	C. & S.

NOTE: C.&S. equals Crushed and Split.

RESULTS OF COMPRESSION TESTS PARALLEL TO GRAIN
SIDE-CUT - NON-INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Lb. per sq. in Elastic Limit	Lb. per sq. in Max. Load	Deflection in. Elastic Limit	Deflection in. Max. Load	Modulus of Elasticity lb. per sq. in.	Type of Failure
1 E	13.60	8	35.5	5754	5961	0.086	0.098	803,000	C. & S.
1 EC	14.78	11	41.0	5617	5645	0.095	0.117	716,000	C. & S.
2 E	14.70	7	36.1	5271	5770	0.108	0.159	585,000	C. & S.
2 EC	15.34	7	55.3	5880	6096	0.094	0.140	750,000	C. & S.
3 E	15.14	12	34.3	7010	7215	0.134	0.153	628,000	C. & S.
3 EC	15.04	11	40.8	5925	6055	0.090	0.107	790,000	C. & S.
4 E	13.82	12	36.3	5968	6090	0.104	0.126	688,000	C. & S.
4 EC	19.94	9	42.7	5522	5846	0.101	0.128	657,000	C. & S.
5 E	10.08	9	26.0	5680	6480	0.099	0.118	689,000	C. & S.
5 EC	16.34	7	42.6	5320	5730	0.073	0.116	607,000	C. & S.
6 E	15.76	10	33.0	5173	5610	0.115	0.161	540,000	C. & S.
6 EC	17.58	10	48.2	4480	4730	0.081	0.102	603,700	C. & S.
7 E	13.86	7	29.9	4480	4900	0.095	0.109	565,000	C. & S.
7 EC	15.16	6	43.4	4480	5005	0.103	0.164	523,000	C. & S.
8 E	13.46	10	34.5	5124	5298	0.139	0.181	442,500	C. & S.
8 EC	16.08	8	39.4	4879	4879	0.089	0.089	658,000	C. & S.
9 E	11.18	10	35.6	4880	5472	0.093	0.133	632,000	C. & S.
9 EC	15.80	9	41.2	4680	5200	0.118	0.186	476,000	C. & S.
10 E	16.80	11	38.5	6680	6732	0.114	0.146	703,000	C. & S.
10 EC	16.82	9	49.4	5269	6150	0.097	0.191	652,000	C. & S.
11 E	15.24	16	32.7	6845	7150	0.136	0.198	605,000	C. & S.
11 EM	14.56	14	42.7	6400	6660	0.100	0.119	666,000	C. & S.
12 E	13.54	12	33.6	6255	6680	0.114	0.162	702,000	C. & S.
12 EM	14.64	8	44.5	6027	6170	0.151	0.174	478,000	C. & S.
13 E	11.30	7	35.1	6925	6925	0.096	0.096	722,000	C. & S.
13 EM	14.80	8	39.1	4480	4855	0.125	0.188	430,000	C. & S.
14 E	16.22	10	44.1	5909	6450	0.119	0.156	597,000	C. & S.
14 EM	16.24	10	49.9	4941	5560	0.079	0.106	624,000	C. & S.
15 E	13.06	11	36.5	6713	7030	0.084	0.117	760,000	C. & S.
15 EM	11.74	9	40.0	7718	7890	0.119	0.146	777,000	C. & S.
16 E	12.38	15	33.3	5210	5800	0.095	0.122	658,000	C. & S.
16 EM	15.36	14	37.3	5162	5960	0.104	0.137	597,000	C. & S.
17 E	10.90	6	33.4	6720	7080	0.126	0.147	666,000	C. & S.
17 EM	14.34	7	43.2	4680	4876	0.119	0.130	472,000	C. & S.
18 E	8.80	12	30.2	5880	6472	0.116	0.138	516,000	C. & S.
18 EM	13.36	10	36.9	5280	5500	0.081	0.109	782,000	C. & S.
19 E	11.84	8	32.1	5968	6318	0.099	0.124	723,000	C. & S.
19 EM	13.66	9	39.8	4279	4425	0.089	0.181	575,500	C. & S.
20 E	14.88	14	36.7	7325	7325	0.111	0.111	792,500	C. & S.
20 EM	13.46	13	40.6	6280	6480	0.093	0.125	810,300	C. & S.

NOTE: C.&S. signifies crushed and split.

RESULTS OF COMPRESSION TESTS PARALLEL TO GRAIN
SIDE-CUT - INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Lb. per sq. in. Elastic Limit	Lb. per sq. in. Max. Load	Deflection in. Elastic Limit	Deflection in. Max. Load	Modulus of Elasticity Lb. per sq. in.	Type of Failure
1 EP	15.66	10	36.8	5890	6120	0.078	0.101	906,000	C. & S.
1 EPC	16.52	9	51.1	5862	6282	0.080	0.093	882,000	C. & S.
2 EP	13.40	7	29.2	3950	4285	0.086	0.118	552,000	C. & S.
2 EPC	14.94	6	39.9	3616	3890	0.093	0.130	469,000	C. & S.
3 EP	13.52	12	38.1	5820	6045	0.097	0.128	722,000	C. & S.
3 EPC	15.60	10	46.1	5175	5300	0.097	0.119	639,000	C. & S.
4 EP	10.00	12	36.6	6305	6320	0.090	0.123	842,000	C. & S.
4 EPC	17.60	9	47.0	5405	5650	0.092	0.108	707,000	C. & S.
5 EP	14.16	7	37.6	6405	6580	0.097	0.117	794,000	C. & S.
5 EPC	16.56	8	48.6	5765	5800	0.076	0.115	910,000	C. & S.
6 EP	14.48	10	30.4	5680	5751	0.133	0.166	512,500	C. & S.
6 EPC	16.78	13	42.7	5530	5920	0.096	0.113	692,000	C. & S.
7 EP	13.96	15	32.6	5080	5402	0.123	0.168	496,000	C. & S.
7 EPC	15.70	14	40.8	4917	5175	0.104	0.156	565,500	C. & S.
8 EP	13.32	8	37.8	6125	6210	0.107	0.143	685,200	C. & S.
8 EPC	17.88	10	49.3	5580	5850	0.101	0.145	662,500	C. & S.
9 EP	13.76	13	32.6	5280	5542	0.124	0.166	512,000	C. & S.
9 EPC	15.86	9	41.3	4793	5096	0.087	0.113	660,000	C. & S.
10 EP	17.28	12	37.4	6260	6475	0.101	0.115	745,000	C. & S.
10 EPC	17.04	11	45.4	5993	6360	0.099	0.129	724,000	C. & S.
11 EP	12.08	13	37.6	5875	6125	0.107	0.132	655,800	C. & S.
11 EPM	16.88	12	53.7	5280	5606	0.114	0.155	555,200	C. & S.
12 EP	11.58	14	55.0	5880	6018	0.095	0.114	743,000	C. & S.
12 EPM	14.68	14	44.6	5360	5500	0.103	0.115	625,000	C. & S.
13 EP	14.26	11	34.4	5540	5775	0.106	0.125	637,500	C. & S.
13 EPM	16.68	10	44.1	4680	4880	0.089	0.114	632,000	C. & S.
14 EP	15.52	12	30.7	5280	5380	0.110	0.135	575,000	C. & S.
14 EPM	16.02	13	41.2	4103	4803	0.086	0.156	572,500	C. & S.
15 EP	14.18	10	34.2	4880	5140	0.105	0.150	555,800	C. & S.
15 EPM	17.24	9	43.7	4180	4580	0.078	0.093	633,000	C. & S.
16 EP	14.88	14	36.2	4880	5278	0.099	0.140	590,000	C. & S.
16 EPM	16.44	12	43.3	4880	5480	0.103	0.139	565,800	C. & S.
17 EP	11.58	12	32.4	5280	5360	0.100	0.124	633,000	C. & S.
17 EPM	15.64	11	39.4	4880	5134	0.138	0.184	425,000	C. & S.
18 EP	16.86	13	35.4	5950	5145	0.101	0.106	714,000	C. & S.
18 EPM	16.76	15	41.9	5145	5510	0.097	0.127	636,000	C. & S.
19 EP	13.64	11	33.5	6000	6400	0.113	0.141	637,500	C. & S.
19 EPM	16.18	11	43.0	3950	4060	0.100	0.150	420,000	C. & S.
20 EP	17.24	8	36.4	5480	5940	0.096	0.126	684,000	C. & S.
20 EPM	16.32	8	43.0	4880	5020	0.084	0.109	697,000	C. & S.

NOTE: C.&S. signifies crushed and split.

Compression Tests Perpendicular to Grain.—Specimens 6 by 6 by 30 in. were also cut from the original transverse specimens to make compression tests perpendicular to grain. The data are tabulated on pages 467 to 470 inclusive. The load was applied to the convex side of the growth rings, through a plate six inches wide as shown by photograph in Fig. 5. An initial load of 500 lb. was applied and deflectometer set at zero. The load was then applied and readings taken in increments of 2500 lb. until the deflectometer registered 0.10 in. after which loads corresponding to $\frac{3}{16}$ and $\frac{3}{8}$ in. deflections were recorded. The photograph Fig. 6 shows characteristic specimens after tests.

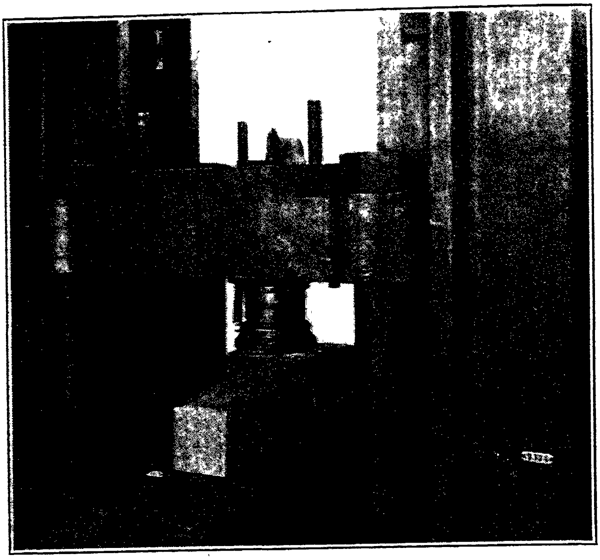


Fig. 5.—Compression Test Perpendicular to Grain, Specimen in Test Machine.

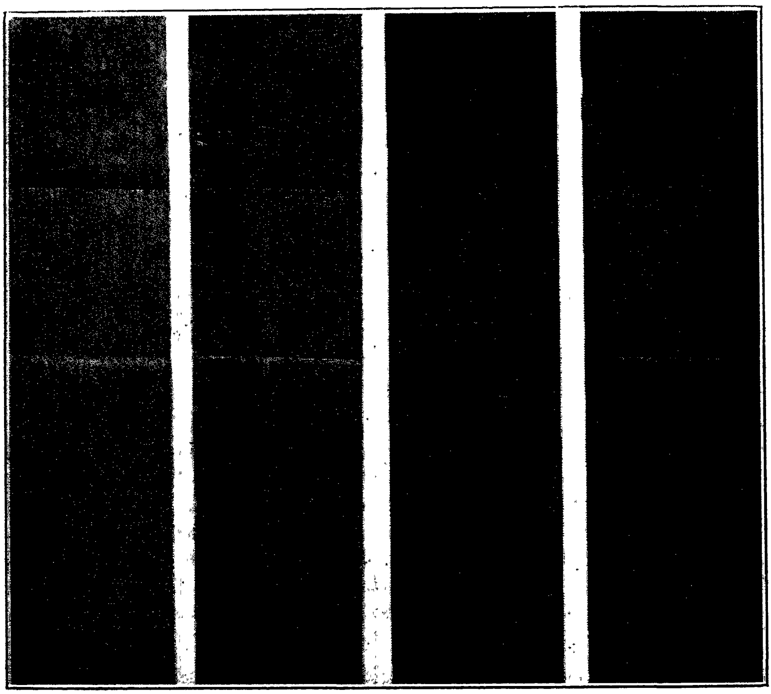


Fig. 6.—Characteristic Failure of Specimens in Compression Test Perpendicular to Grain.

RESULTS OF COMPRESSION TESTS PERPENDICULAR TO GRAIN
BOXED HEART - NON-INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Plastic Limit: Lb. per sq. in.	Plastic Limit: Deflection, in.	Load, lb. per sq.in. for deflection of: 1/10 in.	3/16 in.	3/8 in.	Type of Failure
1 B	11.90	7	30.2	778	0.069	917	991	1,112	C
1 BC	15.18	7	35.3	640	0.117	600	850	[illegible]	C
2 B	11.54	8	31.2	730	0.065	793	878	1,003	C & S
2 BC	15.62	7	45.8	640	0.070	778	959	1,112	C & S
3 B	13.34	12	35.3	850	0.055	887	1,009	1,168	C
3 BC	14.60	13	46.9	913	0.074	1,000	1,195	1,362	C & S
4 B	14.00	8	35.1	917	0.080	983	1,150	1,300	C
4 BC	18.40	9	41.2	1052	0.075	1,112	1,278	1,465	C & S
5 B	13.56	10	31.2	720	0.071	785	933	1,010	C
5 BC	17.76	9	34.8	890	0.069	931	1,018	1,147	C
6 B	14.68	8	33.6	917	0.072	988	1,150	1,250	C
6 BC	20.20	8	44.4	918	0.100	918	1,247	1,370	C
7 B	13.14	9	30.2	786	0.079	920	1,039	1,350	C & S
7 BC	15.02	9	37.6	640	0.048	900	959	1,038	C
8 B	12.34	9	38.4	778	0.087	830	1,103	1,285	C
8 BC	19.38	8	32.2	640	0.057	773	984	1,223	C
9 B	13.44	9	31.2	710	0.078	779	948	1,005	C
9 BC	13.90	10	41.2	778	0.078	918	1,020	1,092	C
10 B	13.10	10	34.2	778	0.092	810	1,000	1,180	C
10 BC	15.60	7	39.7	640	0.063	848	994	1,083	C
11 B	13.90	16	35.5	918	0.068	1,000	1,175	1,385	C
11 BM	14.44	14	37.4	918	0.055	1,195	1,270	1,367	C
12 B	13.84	7	31.3	718	0.086	795	930	1,007	C
12 BM	12.60	9	35.6	709	0.077	792	936	1,065	C
13 B	12.66	9	37.0	873	0.066	1,005	1,145	1,248	C & S
13 BM	12.98	12	41.5	1008	0.060	1,225	1,400	1,400	C & S
14 B	14.98	7	30.1	640	0.100	640	860	1,003	C
14 BM	14.86	6	33.3	709	0.078	723	779	817	C
15 B	14.14	8	32.6	856	0.060	990	110	1,305	C
15 BM	13.38	8	33.7	778	0.062	883	1,000	1,100	C
16 B	10.86	8	31.1	640	0.064	765	830	1,003	C & S
16 BM	15.24	9	45.8	600	0.060	640	816	1,006	C & S
17 B	15.20	6	34.2	778	0.061	850	1,001	1,147	C & S
17 BM	15.82	6	40.2	709	0.082	800	1,015	1,115	C & S
18 B	16.40	8	30.[illegible]	700	0.070	810	915	1,007	C
18 BM	14.88	8	33.5	795	0.065	952	1,068	1,205	C & S
19 B	15.30	11	31.4	845	0.099	860	1,325	1,315	C
19 BM	14.90	9	35.0	778	0.062	883	1,000	1,100	C
20 B	11.26	6	31.8	820	0.067	955	1,006	1,228	C
20 BM	15.06	6	36.4	848	0.063	975	1,040	1,173	C

NOTE: C signifies crushed,
S signifies split.

RESULTS OF COMPRESSION TESTS PERPENDICULAR TO GRAIN
BOXED HEART - INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Plastic Limit: Lb. per sq. in.	Plastic Limit: Deflection, in.	Load, lb. per sq.in. for deflection of 1/10 in.	3/16 in.	3/8 in.	Type of Failure
1 BP	13.22	7	33.2	685	0.100	685	890	1,065	C
1 BPC	16.10	5	39.8	778	0.093	850	1,140	1,318	C & S
2 BP	16.94	8	32.4	640	0.060	778	975	1,130	C
2 BPC	15.62	8	37.5	600	0.101	600	894	1,000	C
3 BP	14.04	14	33.0	645	0.076	715	890	1,003	C
3 BPC	14.72	10	36.4	850	0.072	1,008	1,340	1,470	C
4 BP	13.78	5	32.3	720	0.096	800	930	1,008	C
4 BPC	15.96	6	39.6	850	0.083	915	1,126	1,252	C
5 BP	14.04	7	32.3	710	0.092	770	1,003	1,170	C
5 BPC	15.90	8	38.4	778	0.075	850	967	1,105	C
6 BP	13.94	11	33.5	850	0.090	855	1,003	1,157	C
6 BPC	16.18	13	45.0	850	0.084	926	1,002	1,085	C
7 BP	14.80	8	30.1	790	0.070	918	1,001	1,110	C
7 BPC	14.72	10	39.6	500	0.103	500	652	848	C
8 BP	11.44	8	31.9	700	0.080	778	740	965	C
8 BPC	15.36	8	39.7	641	0.101	641	945	1,014	C
9 BP	11.60	8	37.4	580	0.103	580	785	970	C & S
9 BPC	16.42	10	45.6	570	0.100	570	900	1,033	C
10 BP	12.90	6	34.4	1008	0.066	1,280	1,400	1,538	C
10 BPC	15.70	6	40.3	570	0.100	570	895	846	C & S
11 BP	13.62	8	32.1	795	0.085	866	999	1,200	C
11 BPM	15.88	9	35.3	778	0.065	848	942	1,073	C
12 BP	12.68	9	27.8	640	0.090	685	910	1,141	C
12 BPM	14.82	8	35.1	709	0.079	830	1,190	1,310	C
13 BP	14.52	7	31.8	600	0.150	425	715	1,001	C
13 BPM	14.94	5	38.1	640	0.094	662	863	1,019	C
14 BP	15.60	6	30.7	640	0.068	705	812	935	C
14 BPM	15.32	6	38.0	500	0.080	570	678	850	C
15 BP	11.62	11	33.2	640	0.071	806	948	1,004	C
15 BPM	15.24	11	41.5	709	0.066	848	1,012	1,137	C
16 BP	15.60	9	32.0	848	0.100	848	1,220	1,450	C & S
16 BPM	16.52	8	41.4	848	0.072	986	1,175	1,296	C
17 BP	13.52	9	32.2	918	0.070	1,005	1,248	1,370	C
17 BPM	12.90	8	38.9	843	0.100	843	1,023	1,127	C
18 BP	12.96	9	32.0	640	0.059	755	850	1,002	C & S
18 BPM	15.54	8	36.6	709	0.070	778	867	1,006	C
19 BP	14.00	7	33.0	650	0.120	532	776	1,006	C
19 BPM	16.06	7	41.6	709	0.088	778	1,070	1,218	C
20 BP	11.42	6	33.0	840	0.075	918	1,002	1,195	C
20 BPM	15.22	7	38.2	570	0.100	570	915	1,073	C

NOTE: C signifies crushed,
S signifies split.

RESULTS OF COMPRESSION TESTS PERPENDICULAR TO GRAIN
SIDE-CUT - NON-INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Elastic Limit: Lb. per sq. in.	Elastic Limit: Deflection, in.	Load, lb. per sq. in. for deflection of: 1/10 in.	3/16 in.	3/8 in.	Type of Failure
1 E	13.60	8	35.5	640	0.069	748	880	1,048	C & S
1 EC	14.78	11	41.0	640	0.068	791	929	1,180	C
2 E	14.70	7	36.1	712	0.080	800	965	1,165	C & S
2 EC	15.34	7	55.3	709	0.083	748	1,090	1,352	C
3 E	15.14	12	34.3	747	0.104	740	842	968	C & S
3 EC	15.04	11	40.8	640	0.098	640	888	9[illegible]8	C
4 E	13.82	12	36.3	787	0.086	850	1,013	1,138	C & S
4 EC	19.94	9	42.7	778	0.086	352	1,095	1,245	C
5 E	10.08	9	26.0	700	0.100	700	840	982	C & S
5 EC	16.34	7	42.6	639	0.086	700	835	1,000	C
6 E	15.76	10	33.0	555	0.103	555	723	929	C & S
6 EC	17.58	10	48.2	639	0.137	580	710	910	C & S
7 E	13.86	7	29.9	654	0.097	654	782	917	C
7 EC	15.16	6	43.4	639	0.114	600	805	972	C
8 E	13.46	10	34.5	569	0.082	621	760	896	C
8 EC	16.08	8	39.4	639	0.082	700	882	1,020	C & S
9 E	11.18	10	35.6	576	0.086	646	747	866	C
9 EC	15.80	9	41.2	639	0.117	600	750	850	C
10 E	16.80	11	38.5	778	0.087	838	980	1,118	C
10 EC	16.82	9	49.4	778	0.082	851	1,022	1,195	C
11 E	15.34	16	38.7	640	0.081	712	864	1,018	C & S
11 EM	14.56	14	42.7	850	0.100	850	1,002	1,112	C
12 E	13.54	12	33.6	653	0.084	718	912	1,068	C
12 EM	14.64	8	44.5	570	0.094	600	882	1,009	C & S
13 E	11.30	7	35.1	506	0.065	590	684	900	C
13 EM	14.80	8	89.1	500	0.101	500	723	803	C & S
14 E	16.52	10	44.1	709	0.088	770	910	1,083	C
14 EM	16.24	10	49.9	788	0.099	788	1,100	1,280	C
15 E	13.06	11	36.5	640	0.084	726	960	1,134	C
15 EM	11.74	9	40.0	600	0.125	500	850	1,000	C & S
16 E	12.38	15	33.3	786	0.079	860	978	1,108	C & S
16 EM	12.36	14	37.3	850	0.071	987	1,150	1,235	C
17 E	10.90	6	33.4	730	0.070	778	872	1,007	C
17 EM	14.34	7	43.2	640	0.103	640	850	985	C
18 E	8.80	12	30.2	640	0.062	734	895	1,040	C & S
18 EM	13.36	10	36.9	648	0.102	648	894	1,000	C & S
19 E	11.84	8	32.1	600	0.060	677	784	922	C
19 EM	13.60	9	39.8	710	0.086	770	945	1,008	C
20 E	14.88	14	36.7	640	0.068	768	858	1,038	C
20 EM	13.46	13	40.6	690	0.101	690	880	1,003	C & S

NOTE: C signifies crushed,
S signifies split.

RESULTS OF COMPRESSION TESTS PERPENDICULAR TO GRAIN
SIDE-CUT - INCISED

Specimen Number	Moisture %	Rings per in.	Wt. per cubic foot	Plastic Limit: Lb. per sq. in.	Plastic Limit: Deflection, in.	Load, lb. per sq. in. for deflection of 1/10 in.	3/16 in.	3/8 in.	Type of Failure
1 EP	15.66	10	36.8	604	0.101	604	845	1,120	C
1 EPC	16.52	9	51.1	640	0.083	700	972	1,145	C
2 EP	13.40	7	29.2	651	0.081	738	886	1,001	C & S
2 EPC	14.94	6	39.9	640	0.095	700	876	970	C
3 EP	13.52	12	38.1	778	0.100	778	958	1,089	C & S
3 EPC	15.60	10	46.1	778	0.095	834	1,032	1,200	C
4 EP	10.00	12	36.6	730	0.099	730	885	1,109	C
4 EPC	17.60	9	47.0	889	0.100	889	1,073	1,190	C
5 EP	14.16	7	37.6	608	0.103	608	840	1,001	C & S
5 EPC	16.56	8	48.6	778	0.101	778	973	1,110	C
6 EP	14.48	10	30.4	590	0.100	590	790	1,001	C
6 EPC	16.78	13	42.7	640	0.102	640	785	967	C
7 EP	13.96	15	32.6	625	0.106	600	730	920	C
7 EPC	15.70	14	40.8	640	0.101	640	806	973	C
8 EP	13.32	8	37.8	860	0.100	860	995	1,162	C & S
8 EPC	17.88	10	49.3	640	0.100	640	924	1,196	C
9 EP	13.76	13	32.6	780	0.103	780	930	1,005	C
9 EPC	15.96	9	41.3	778	0.100	778	930	1,047	C
10 EP	17.28	12	37.4	944	0.105	915	1,006	1,233	C & S
10 EPC	17.04	11	45.4	918	0.102	918	1,100	1,195	C
11 EP	12.08	13	37.6	800	0.120	630	960	989	C & S
11 EPM	16.33	12	53.7	780	0.120	646	968	1,155	C
12 EP	11.58	14	55.0	656	0.102	656	793	925	C & S
12 EPM	14.63	14	44.6	709	0.090	716	1,098	1,310	C
13 EP	14.26	11	34.4	650	0.102	650	823	982	C
13 EPM	16.68	10	44.1	778	0.100	778	1,013	1,138	C
14 EP	15.52	12	30.7	600	0.138	509	709	806	C
14 EPM	16.02	13	41.2	658	0.100	658	930	1,008	C
15 EP	14.18	10	34.2	530	0.101	530	680	822	C & S
15 EPM	17.24	9	43.7	500	0.100	500	671	823	C
16 EP	14.38	14	36.2	725	0.101	725	858	1,001	C
16 EPM	16.44	12	43.3	570	0.098	570	792	869	C & S
17 EP	11.58	12	32.4	716	0.090	753	900	1,040	C
17 EPM	15.64	11	39.4	700	0.116	641	923	1,050	C
18 EP	16.86	13	35.4	536	0.102	536	690	848	C
18 EPM	16.76	15	41.9	600	0.125	525	644	760	C
19 EP	13.64	11	33.5	720	0.104	710	856	1,022	C
19 EPM	16.18	11	43.0	695	0.100	695	893	1,002	C
20 EP	17.24	8	36.4	706	0.100	706	967	1,160	C
20 EPM	16.32	8	43.0	588	0.100	588	876	1,010	C & S

NOTE: C signifies crushed,
S signifies split.

SUMMARY OF COMPRESSION TESTS:

Specimen	Parallel to grain: Pounds per sq. in.: Elastic limit	Modulus of rupture	Per cent change: Elastic limit	Modulus of rupture	Perpendicular to grain: Lb. per sq. in. elastic limit	Per cent change Elastic limit
		Effect of Treatment				
1-10 B	5735	6112			796	
1-10 BC	5365	5701	-6.46	-6.72	775	-2.64
11-20 B	5010	5567			779	
11-20 BM	5214	5536	+4.07	-0.56	775	-0.51
1-10 BP	5242	5572			733	
1-10 BPC	5062	5405	-3.43	-2.95	699	-4.64
11-20 BP	5164	5422			721	
11-20 BPM	4972	5269	-3.72	-2.82	701	-2.77
1-10 E	5602	5953			672	
1-10 EC	5205	5534	-7.10	-6.88	674	+0.30
11-20 E	6375	6723			654	
11-20 EM	5525	5837	-13.34	-13.15	684	+4.59
1-10 EP	5679	5873			718	
1-10 EPC	4727	5532	-16.75	-5.82	734	+2.20
11-20 EP	5504	5656			664	
11-20 EPM	4727	5057	-14.11	-10.59	658	-0.90
		Effect of Incisions on Untreated Specimens				
1-20 B	5372	5839			778	
1-20 BP	5203	5497	-3.15	-5.86	727	-6.56
1-20 E	5988	6388			663	
1-20 EP	5591	5764	-6.63	-9.77	691	+4.22
		Effect of Incisions on Treated Specimens				
1-10 BC	5365	5701			775	
1-10 BPC	5062	5405	-5.65	-5.19	699	-9.78
11-20 BM	5214	5536			775	
11-20 BPM	4972	5269	-4.64	-4.83	701	-9.55
1-10 EC	5205	5534			674	
1-10 EPC	4727	5532-	-9.20	-0.04	734	+8.90
11-20 EM	5525	5837			684	
11-20 EPM	4727	5075	-14.44	-13.29	658	-3.86

MOISTURE.—Samples for determining the percentage of moisture were taken by boring nine holes evenly distributed over a newly sawed section of the original specimen. In the case of the creosoted specimen the samples were taken from inside the area of penetration except in a few cases where it was impossible to do so. These samples were put in an electric oven and heated until all moisture was evaporated thus determining the percent of moisture by weight. Moisture percentages are given next the specimen number in the tabulation of data.

PHENOMENA OBSERVED DURING TRANSVERSE TEST.—In most cases failure did not occur until after the elastic limit was reached. Most of the failures were from horizontal shear. After the shear failure, the load dropped and built up again, the specimen acting as two beams one on top of the other. In case of tension failure, the specimen failed suddenly by tension in the lower fibre. Checks seemed to be the most controlling factor of the strength of the stringers. Checking was more noticeable in the boxed heart specimens than in the side-cut.

SUMMARY OF RESULTS.—The results of the tests are summarized in the tables on pages 460 and 471 showing the effects of treatment and incisions on both side-cut and boxed heart specimens. The plus and minus signs in the last two columns under effect of treatment, indicate a gain or loss of strength of the treated specimens over corresponding untreated specimens. The effect of the incisions on both untreated and treated specimens is last shown, but the comparison in this case is not the same pieces of original 30-foot stringers. In the summary of the transverse tests, there is also shown a comparison of the side-cut to boxed heart in bending. The averages of all specimens tested could be briefly tabulated as follows:

COMPARISON AT ELASTIC LIMIT

	Transverse	*Per Cent Compression* Parallel to grain	*Per Cent Compression* Perpendicular to grain
Decrease in strength:			
Due to treatment	1.0	7.5	0.5
Due to incisions:			
Untreated specimens	10.5	5.0	1.0
Treated specimens	7.5	9.0	4.0
Increase in strength, side-cut over boxed heart:			
Untreated:			
Non-incised	8.0		
Incised	3.5		
Treated:			
Non-incised	6.5		
Incised	5.0		

DISCUSSION.—Due to variations in grain structure and the variations of defects in structural sizes of timbers, a noticeable difference at failure will exist in different specimens.

The modulus of rupture in bending is low in most cases since it is not the ultimate bending stress but is the stress at which horizontal shear occurred. The checks in the stringers were an important factor in causing horizontal shear failures.

The modulus of elasticity is lower in the case of the incised specimens than the non-incised. This difference, in general, is not very great. It will be noted on pages 458 and 459 inclusive that in some instances the difference is quite great. Should two or more stringers be placed side by side, the one with the greater modulus of elasticity would necessarily have to carry more than its share of the load. This would account for a stringer failure even though according to computation it had not reached its ultimate stress.

Conclusions

In the following the comparisons are made at the elastic limit:

1. Treatment decreased the bending stress and compression perpendicular to grain a negligible amount. Compression parallel to grain was decreased about 7½ per cent.

2. Incisions decreased the strength of untreated specimens 10½ per cent in bending, 5 per cent in compression parallel to grain and 1 per cent perpendicular to grain.

3. Incisions decreased the strength of treated specimens 7½ per cent in bending, 8 per cent in compression parallel to grain and 4 per cent in compression perpendicular to grain.

4. In the untreated specimens the side-cut was 8 per cent stronger than the boxed heart when not incised and 3½ per cent stronger when incised.

5. In the treated specimens, the side-cut was 5½ per cent stronger than the boxed heart when not incised and 5 per cent when incised.

While the foregoing tests do indicate a reduction in strength of the timber caused by incising, nevertheless this loss in strength is so small as compared with the excess strength which is provided in all modern bridge design, it is our conclusion that the reduction in strength may be practically disregarded. On the other hand, incising results in a decided improvement in quality of treatment as explained earlier in this report. Your Committee, therefore, recommends that Douglas fir ties and all lumber more than 2 in. in thickness be incised 4 sides, the incisor teeth to be not more than $\frac{5}{32}$ in. thick and the pattern for the placing of the incisions similar to that shown by Fig. 1. Incisions ¾ in. in depth are recommended for all sawed Douglas fir 6 in. thick or over, and the incisions ½ in. in depth in the sides and ¾ in. deep in the edges, of all sawed fir less than 6 in. thick and more than 2 in. in thickness. Incising of material less than 2 in. in thickness is not recommended.

TREATMENT

During the past year or more the Committee have been carrying on test treatments in an experimental treating plant, along the lines of the treatment of air-seasoned Douglas fir now being used. Approximately one hundred fifty test treatments were made, the object of the experiments being to manipulate the temperatures, preservative pressures, time of holding preservative pressure, amount and duration of air pressure, etc. so as to secure the deepest and most uniform penetration of preservative in air-seasoned fir without physical damage to the wood. Without taking space in this report for the large amount of data accumulated, general conclusions reached may be stated as follows:

1. There is a wide variation in the wood structure of individual pieces of Douglas fir, and there will, therefore, be considerable variation in the absorption and penetration of preservative in individual pieces in any charge treated. This variation in penetration and absorption will be minimized, but will still exist in incised timbers. In general, close-grain treats more readily than wide ring fir.

2. One of the most important features in connection with the successful treatment of air-seasoned fir is to get the right degree of seasoning. It is quite possible to over-season in most climates and reach a so-called "case-hardened" condition. Wood in this condition requires more severe treatment to secure satisfactory penetration of the preservative. The Committee is of the opinion that under average conditions, fir seasoned to a moisture content of 15 to 20 per cent in the marginal two inches of any cross-section is in satisfactory condition to treat. It is essential to establish the seasoning period for each class of Douglas fir for any particular locality, of sufficient length to bring about the above results.

3. High pressures, particularly when combined with high temperatures, are detrimental to Douglas fir, and the wood structure may be seriously damaged, if safe limits are not observed. The Committee has reached the conclusion that 100 lb. per sq. in. is a safe and satisfactory maximum pressure to use in the treatment of air-seasoned fir, except in the treatments using initial air pressure, in which a maximum pressure 75 to 100 lb. greater than the initial air pressure, but in no case more than 175 lb. per sq. in., may be used. Likewise, a treating cylinder temperature of 200 deg. F. will not damage the timber when used with pressures given above. It is advisable to use treating cylinder temperatures between 190 deg. F. and 200 deg. F. to secure maximum penetration. The treating cylinder temperature may be increased to 220 deg. F. for a short period of time, as an "expansion bath", which may be used following the pressure period and in connection with the final vacuum.

4. Various conditions, particularly conditions under which the timber is seasoned will affect the time required for the pressure period. The Committee feel, however, that it is good practice not to exceed a 12 hr. period at maximum pressure when treating sawed timbers and a 16 hr. pressure period when treating piling, poles and other round timbers. It is important, however, that Douglas fir should be treated to practical refusal at 100 lb. maximum pressure.

5. When timber has been over-seasoned and in the condition known as "case-hardened", or due to cold weather, it may be found advantageous to heat the timber by holding in the preservative without pressure at a temperature of as near 200 deg. F. as possible, for a period of not more than 6 hr.

As a result of its study of the methods now used by those who have been treating air-seasoned Douglas fir for some years, plus such information as has been developed by the experimental work carried on during the past year or more, your Committee presents as information, "Specifications for the Treatment of Air-Seasoned Douglas Fir", with the recommendation that they be referred to other interested committees for consideration and criticism, with a view to later presenting the revised specifications for inclusion in the Manual.

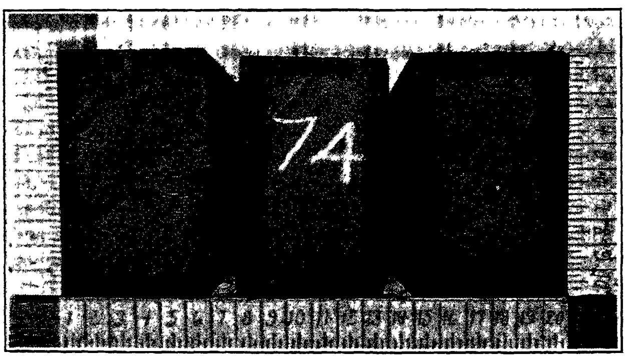


FIG. 7.—Cross-sections from 6 × 10–14-ft. Air-Seasoned Douglas Fir treated with Creosote by Lowry Process in experimental charge No. 81. Cross-sections 4-ft. 6-in. from ends and are from the pieces in the charge taking the low, average, and high absorption of creosote. This charge was given a 4-hour warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 2 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.
Absorption of Creosote, lb. per cu. ft. of Timber, left to right, 3.95, 8.06, 11.15.

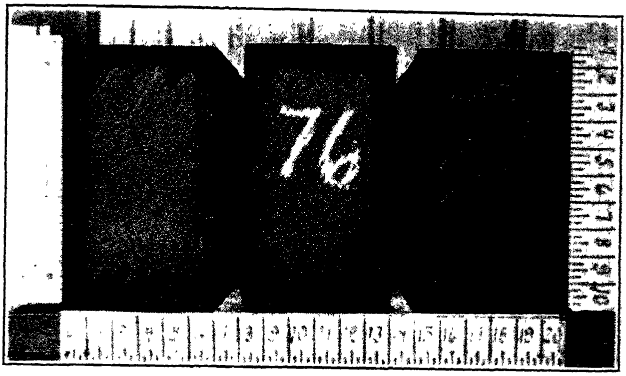


FIG. 8.—Cross-sections from 6 × 10–14-ft. Air-Seasoned Douglas Fir treated with Creosote by Lowry Process in experimental charge No. 99. Cross-sections 4-ft. 6-in. from ends and are from the pieces in the charge taking the low, average, and high absorption of creosote. This charge was given a 4-hr. warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 4 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.

Absorption of Creosote, lb. per cu. ft. of Timber, left to right, 7.72, 9.26, 13.21.

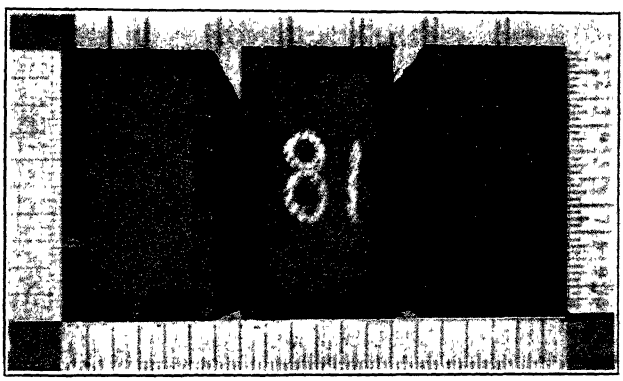


FIG. 9.—Cross-sections from 6 × 10–16-ft. Air-Seasoned Douglas Fir treated with Creosote by Lowry Process in experimental charge No. 104. Cross-sections 5-ft. from ends and are from the pieces in the charge taking the low, average and high absorption of creosote. This charge was given a 4-hour warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 6 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.

Absorption of Creosote, lb. per cu. ft. of Timber, left to right, 5.40, 8.40, 14.09.

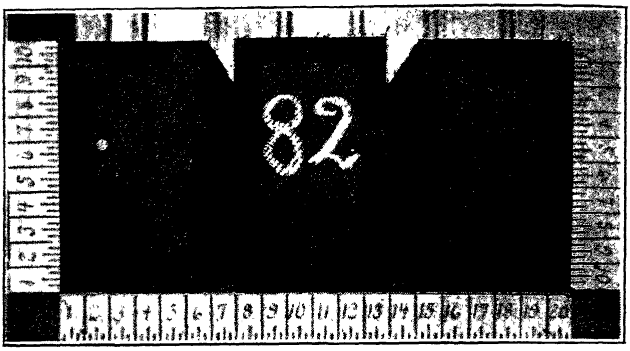


FIG. 10.—Cross-sections from 6 × 10–16-ft. Air-Seasoned Douglas Fir treated with Creosote by Lowry Process in experimental charge No. 105. Cross-sections 5-ft. from ends and are from the pieces in the charge taking the low, average and high absorption of creosote. This charge was given a 4-hour warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 6 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.

Absorption of Creosote, lb. per cu. ft. of Timber, left to right, 5.10, 7.95, 11.69.

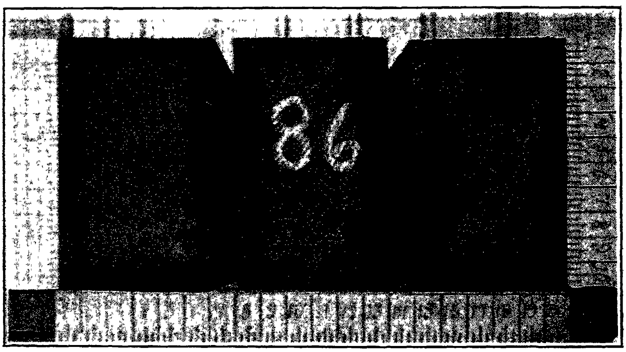


FIG. 11.—Cross-sections from 6 × 10–16-ft. Air-Seasoned Douglas Fir treated with Creosote by Lowry Process in experimental charge No. 109. Cross-sections 5-ft. from ends and are from the pieces in the charge taking the low, average, and high absorption of creosote. This charge was given a 4-hour warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 8 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.

Absorption of Creosote, lb. per cu. ft. of Timber, left to right, 6.75, 8.40, 11.09.

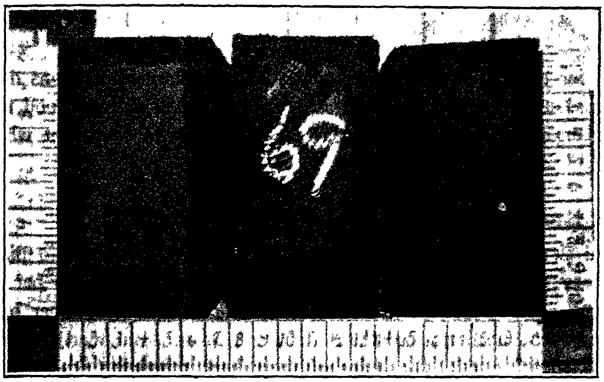


FIG. 12.—Cross-sections from 6 $\times$ 10–14-ft. Air-Seasoned Douglas Fir treated with Creosote by Lowry Process in experimental charge No. 96. Cross-sections 4-ft. 6-in. from ends and are from the pieces in the charge taking the low, average, and high absorption of creosote. This charge was given a 2-hour warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 10 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.
Absorption of Creosote, lb. per cu. ft. of Timber, left to right, 6.52, 11.84, 15.27.

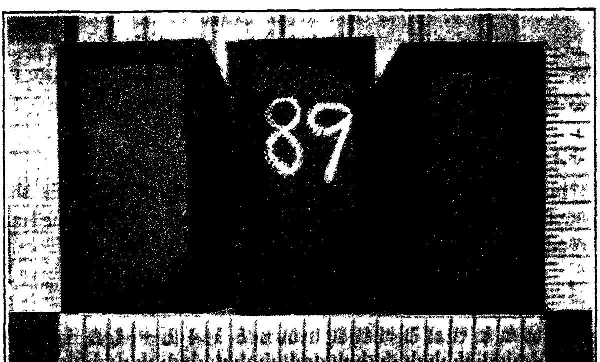


FIG. 13.—Cross-sections from 6 $\times$ 10–16-ft. Air-Seasoned Douglas Fir Treated with Creosote by Lowry Process in experimental charge No. 120. Cross-sections 5-ft. from ends and are from the pieces in the charge taking the low, average, and high absorption of creosote. This charge was given a 4-hour warming bath in creosote heated to 200° Fahr., then pressure built up to 100-lb. per sq. in. in 30 min. and this maximum held 10 hours. Temperature of creosote during pressure 200° Fahr. Final vacuum held 1 hour.
Absorption of Creosote lb. per cu. ft. of timber, left to right, 4.95, 7.95, 10.34.

SPECIFICATIONS FOR THE TREATMENT OF AIR SEASONED DOUGLAS FIR

Material

Material for treatment shall be in accordance with the specifications of this Association. Special attention, however, is directed to the peeling and sapwood requirements of round timbers which have direct bearing on the quality of treatment which may be secured.

Peeling and Sapwood Requirements of Round Timbers

All round timbers shall be thoroughly peeled before treatment. No piece shall be considered thoroughly peeled unless all the rough bark and at least 80 per cent of the inner bark shall have been removed. In no case shall any piece of inner bark be over ¾ in. wide or over 8 in. long, and there shall be 1 in. of clean wood surface between any two such strips. Should the strips of inner bark remaining on the pole be less than ¾ in. wide, the clear space required between any two such strips may be proportionally less than 1 in. No circumference may have more than 20 per cent of its surface covered with inner bark, although the entire surface of the pole may contain less than the allowable 20 per cent.

Piling and poles shall have sapwood of a minimum thickness of 1 in. at the butt end.

Seasoning

Douglas fir shall be air seasoned under conditions in accordance with the recommended practice of this Association. Since the rate of seasoning varies with the latitude, time of year, the exposure, and the climatic peculiarities of the season, it is essential to establish the seasoning period for each class of Douglas fir for any particular locality. The seasoning period shall be of sufficient length to reduce the moisture content of the marginal two inches of any cross-section of round or sawed timbers to 20 per cent, or less, of its oven dry weight. In material less than 4 in. in thickness, entire cross-sections shall be considered.

Adzing, Boring and Framing

Insofar as practicable, all adzing, boring and framing of all kinds shall be done before treatment to minimize subsequent cutting through the treated shell and exposure of untreated wood.

Incising

All sawed Douglas fir shall be incised two sides and two edges, using incisor teeth not more than $\frac{5}{32}$ in. thick. Incisions ¾ in. in depth are recommended for all sawed fir six inches thick or over, and ½ in. in depth in sides and ¾ in. in the edges of all sawed fir less than 6 in. and more than 2 in. in thickness. Incising of material less than 2 in. in thickness is not recommended. The pattern recommended for the placing of the incisions is shown by Fig. 1.

Grouping for Treatment

It is essential that Douglas fir be grouped properly in order that successful treatment may be obtained. Any charge shall be confined to pieces of approximately equal sapwood and moisture content, into which approximately equal quantities of preservative can be injected, and so separated as to insure contact of preservative with all surfaces.

TREATMENT

General

The ranges of pressure, temperature, and time duration shall be controlled so as to result in maximum penetration by the quantity of preservative injected, which shall permeate all the sapwood, and as much of the heartwood as practicable. The vacuum requirements stipulated are those of sea level and necessary corrections shall be made for altitude.

Retention of Preservative

No charge shall contain less than 90 per cent nor more than 120 per cent of the quantity of preservative that may be specified; but the average retention of the preservative by the material treated under any contract or order shall be at least 100 per cent of the quantity specified.

The amount of preservative retained shall be calculated on the basis of preservative at 100° Fahr., from readings of working tank gages, or scales, or from weights before and after treatment of loaded trams on suitable track scales, with a correction for difference in moisture content, and checked as may be desired by the purchaser's representative.

Determination of Penetration

Penetration shall be determined by sampling material in each charge, as may be desired by the purchaser's representative. Any holes which may be bored shall be filled with tight-fitting treated plugs.

Plant Equipment

Treating plants shall be equipped with the thermometers and gages necessary to indicate accurately and record the conditions at all stages of treatment, and all equipment shall be maintained in condition satisfactory to the purchaser. The apparatus and chemicals necessary for making analyses and tests required by the purchaser shall also be provided by plant operators and kept in condition for use at all times.

Preservative

The preservative used shall conform to one of the following standards of this Association:

Creosote, classes one, two or three.
Creosote-Coal Tar Solution.
Zinc Chloride.

Amount of Preservatives to be Used—Douglas Fir for General Construction

(a) Creosote

Full Cell Process, not less than 10 lb. per cu. ft. of timber or to refusal.

Rueping Process, not less than 6 lb. per cu. ft. of timber.

Lowry Process, not less than 6 lb. per cu. ft. of timber.

(b) Zinc Chloride

Not less than ½ lb. of dry salt per cu. ft. of timber.

(c) Creosote-Zinc Chloride

Not less than 2 lb. of creosote and ½ lb. dry zinc chloride per cu. ft. of timber.

Amount of Preservative to be Used—Douglas Fir for Use in Salt Water

Creosote—Not less than 12 lb. per cu. ft. of timber.

Other preservatives are not recommended for this class of service.

TREATING OPERATIONS

Ties, Structural Timbers and Lumber of All Sizes

Creosote Treatments

Heating

Preliminary to the pressure period, it may be found advantageous to heat the air-seasoned timber. When this is the case, the treating cylinder may be filled with the preservative heated to a temperature of 180° F. to 200° F. and held to as nearly 200° F. as possible for not more than 6 hr.

Full Cell Process

Following the heating period, or as the first stage of the treatment, if no heating period used, a vacuum of not less than 22 in. shall be speedily created and maintained for a period of not less than 30 min. so that the timber may be as free from air as practicable. Without breaking the vacuum, the treating cylinder shall be filled with preservative heated to a temperature of 180° F. to 200° F. The pressure shall then be gradually raised to a maximum of 100 lb. per square inch over a period of not less than 30 min. nor more than 1 hr. and 30 min., and maintained until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or failing this, until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. In no case, however, shall the period of maximum pressure exceed 12 hr. The temperature of the preservative during the pressure period shall not be less than 180° F. nor more than 200° F. and shall average at least 190° F.

After pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum of at least 22 in. promptly created and maintained until the timber can be removed from the cylinder free of dripping preservative.

Rueping Process

Following the heating period, or as the first stage of the treatment, if no heating period is used, the timber shall be subjected to air pressure of sufficient intensity and duration to provide, under a vacuum, the ejection of surplus preservative and to insure proper distribution and maximum penetration of the stipulated number of pounds of preservative per cubic foot of wood.

The preservative shall be introduced between 180° F. and 200° F., the pressure being maintained constant until the cylinder is filled with preservative. The pressure shall then be gradually raised over a period of not less than 30 min. nor more than 1 hr. and 30 min. to a minimum of 125 lb. per square inch and maintained within a maximum of 175 lb. per square inch, but in no case shall exceed 100 lb. more than the air pressure used, until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum, or, failing this, until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. In no case, however, shall the period of maximum pressure exceed 12 hr. The temperature of the preservative during the pressure period shall be not less than 180° F., nor more than 200° F., and shall average at least 190° F.

After pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum of at least 22 in. promptly created and maintained until the timber can be removed from the cylinder free of dripping preservative. As an alternative, both additional heat and vacuum may be applied as follows. After pressure is completed and before removal of preservative from the cylinder, the preservative surrounding the timber

may be heated to a maximum of 220° F., the steam to be turned off the heating coils immediately the maximum temperature is reached. The preservative shall then be removed from the cylinder and a vacuum applied as specified above.

Lowry Process

Following the heating period, or as the first stage of the treatment, if no heating period is used, the treating cylinder shall be filled with the preservative, heated to a temperature of 180° F. to 200° F. Pressure shall then be gradually raised to a maximum of 100 lb. per square inch over a period of not less than 30 min. nor more than 1 hr. and 30 min. and maintained until there is obtained the largest volumetric injection practicable that can be reduced to the required retention by quick high vacuum, or, failing this, until the purchaser's representative is satisfied that the largest volumetric injection that is practicable has been obtained. In no case, however, shall the period of maximum pressure exceed 12 hr. The temperature of the preservative during the pressure period shall not be less than 180° F. nor more than 200° F. and shall average at least 190° F.

After pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum of at least 22 in. promptly created and maintained for not less than 30 min. until the quantity of preservative injected is reduced to the required retention and the timber can be removed from the cylinder free of dripping preservative. As an alternative, both additional heat and vacuum may be applied as follows. After pressure is completed, and before removal of preservative from the cylinder, the preservative surrounding the timber may be heated to a maximum of 220° F., the steam to be turned off the heating coils immediately the maximum temperature is reached. The preservative shall then be removed from the cylinder and a vacuum applied as specified above.

Zinc Chloride Treatment

The treating solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption practicable and shall be thoroughly mixed before use.

The timber shall first be subjected to a vacuum of not less than 22 in. for at least 30 min. before the preservative is admitted to the cylinder. The preservative shall be introduced between 180° F. and 200° F., without breaking the vacuum until the cylinder is filled. The pressure shall then be gradually raised to a maximum of 100 lb. per square inch over a period of not less than 30 min. nor more than 1 hr. and 30 min. and maintained until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or until less than 2 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at the maximum. In no case, however, shall the period of maximum pressure exceed 12 hr. The temperature of the preservative during the pressure period shall not be less than 180° F. nor more than 200° F. and shall average at least 190° F.

After the pressure is completed, the cylinder shall be speedily emptied of preservative and a vacuum promptly created and maintained until the timber can be removed from the cylinder free of dripping preservative.

Creosote-Zinc Chloride Treatment

The preservative mixture shall be composed of the volumetric proportions of creosote and zinc chloride solution of the necessary strength required to obtain the stipulated retention with the largest volumetric injection that is practicable, and shall be agitated in the working tank and treating cylinder so as to insure thorough mixing before and

while the cylinder is being filled with preservative and while the preservative is being injected into the timber.

The timber shall first be subjected to a vacuum of not less than 22 in. for at least 30 min. before the preservative is admitted to the cylinder.

The treating cylinder shall be filled with the mixture of preservatives heated to a temperature of 180° F. to 200° F. without breaking the vacuum. The pressure shall then be raised to a maximum of 100 lb. per square inch over a period of not less than 30 min. nor more than 1 hr. and 30 min. and maintained until the quantity of preservative required to insure the final retention stipulated is injected into the wood, or until less than 2 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased, while the pressure has been held continuously at the maximum. In no case, however, shall the period of maximum pressure exceed 12 hr. The temperature of the preservative during the pressure period shall not be less than 180° F. nor more than 200° F. and shall average at least 190° F.

After pressure is completed, the cylinder shall be emptied speedily of preservative and a vacuum promptly created and maintained until the timber can be removed from the cylinder free of dripping preservative.

Treating Operations

Piles and Poles

Specifications for treating operations covering piles and poles are the same as those covering ties, structural timber and lumber, except that the period of maximum pressure of preservative in all treatments may be held to a limit of 16 hr. instead of 12 hr. as in the treatments of sawed timber.

Conclusion

It is recommended that this report be accepted as information.

Appendix E

(5) DESTRUCTION BY TERMITE AND POSSIBLE WAYS OF PREVENTION

Dr. Hermann von Schrenk, Chairman, Sub-Committee; W. G. Atwood, C. C. Cook, L. H. Harper, F. D. Mattos, L. B. Shipley, W. A. Summerhays, C. M. Taylor, G. R. Hopkins.

During the past year, the Committee has continued its investigation reference termite activities and termite control and it presents the following report with the recommendation that it be received as information and the subject continued.

Termite activities have been reported in apparently increasing numbers from all over the United States, with the possible exception of several of the North Central States. Whether the increased number of cases noted is due to the increasing activities of these insects or whether it is to be ascribed to greater familiarity with the results of their attack, it is difficult to state. The number of cases reported, however, seem to warrant giving this matter increased attention, particularly in the construcion of buildings. The Committee wishes again to strongly recommend that the safeguards described in our earlier reports (Proceedings A.R.E.A., Vol. 31, pages 741–748: 1930) be seriously considered whenever new buildings are being constructed. This refers particularly to the use of cement mortar for foundation walls and above all, to the placing

of termite metal shields on top of the foundation walls or wherever concrete slabs come in contact with walls or other slabs.

In the last year's report of this Committee, a warning issued by the Government was printed in full. This refers particularly to the necessity for being cautious about using so-called "soil poisons" because of the fact that so far as it was known, there was grave doubt as to whether these soil poisons would have any long-term efficiency in preventing termite attack.

In order to determine the efficiency of soil poisons, a test was started by the Chairman of the Committee at Florissant, Missouri, in May, 1932. Pieces of 2×4 of wide-ringed southern pine were driven into the ground in a section of land where termite destruction had been very manifest during the past 8 or 10 years. For each of the soil poisons to be tested, 5 posts were used; 4 of them treated with the soil poison and one left untreated as a control. After the pieces had been driven into the ground leaving about 6 inches exposed above the ground, the soil poisons were applied to the soil around the posts in liquid form, with one or two exceptions. This application consisted in pouring the liquid into a shallow basin about one foot in diameter formed around the 2×4. In the case of the solids, they were placed well below the ground level around the 2×4. Each post was then covered with a piece of heavy roofing felt to shelter each piece against rain and snow and reduce the probability of direct leaching. The following substances were used in this test:

Magnesium fluosilicate
Sodium fluosilicate
Borax
Sodium chloride
Sodium arsenite
Orthodichlorbenzene
Paradichlorbenzene
Solvent "75" (Hooker)
Trichlorbenzene
Alphachlornaphthalene
Orthophenylphenol
Dichlororthophenyl
Sodium orthophenylphenate
Sodium dichlorphenylphenate
Betanaphthol
Creosote
Terminix
Termiteol
Anaconda Treater Paste
Crankcase oil
Lead Arsenate
Water and Crankcase oil

These posts have been left undisturbed since their insertion. It is anticipated they will be pulled for examination sometime in June or July of 1933. A number of additional tests were undertaken since the installation of these posts, to determine possible destruction of a number of these soil poisons, particularly as to depth of penetration for a given quantity of the solution as well as lateral penetration through the soil. It is hoped to give some detailed results of these experiments in our next year's report.

NOTES ON THE WHARF BORER

Engineers in the vicinity of New York City were puzzled this year to find borers in piling above the plane of high water and in no case in the submerged portion of the piles. The piles appeared to be sound on the outside but gave a hollow sound when struck and the inside was almost entirely destroyed by borers. Marine worms could

not have caused this damage which was due to the young of a winged beetle—"the wharf borer" *(Nacerda melanura* Linn.).

This oedemerid beetle lays its small, kidney-shaped eggs in cracks and crevices of the piling; flying about it would be mistaken in general appearance for a firefly. About half an inch in length this slender elongate beetle has black tips to the wing covers. It flies in April and June at Washington, D. C., and in July on Puget Sound.

Introduced from Europe this wood-boring insect is now cosmopolitan in its distribution. In this country it has been found in Massachusetts (Boston and Woods Hole), Greater New York, New Jersey (Sea Isle City), Maryland (Baltimore), Virginia (Norfolk), Georgia (Savannah), Florida, Louisiana (New Orleans), Alabama (Magazine Point), Michigan (Detroit), New Mexico, California and Washington (Puget Sound).

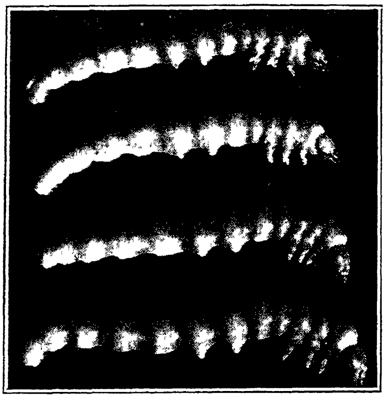


PHOTO NO. 1.—Larvae of Wharf Borer (Times two).

The young larvae (Fig. 1) damage piling, wharves, bridges, telephone poles, conduits, paving blocks, the woodwork of buildings, etc. Similar damage has been reported from the Bahamas, Denmark and New Zealand. Occasionally these borers have been found in creosoted wood and there is still some doubt as to whether the insect will attack thoroughly creosoted timber because the evidence is somewhat conflicting. One of the points which is not yet settled is whether this borer will attack sound wood; it is known that they will work from decayed wood into sound wood.

The appearance of these borers was called to the attention of the Committee because of recent attacks in piling in New York City and Brooklyn. Two photographs herewith attached show the general nature of destruction in two pine piles of the New York Dock Company, removed in February, 1932. The Committee presents this data with the suggestion that they would be glad to be advised preferably with samples, should attacks similar to these be noted. The Committee is indebted to R. H. Mann for the photographs of damage and to Dr. T. E. Snyder of the Bureau of Entomology, Washington, D. C., and Col. Wm. G. Atwood for the foregoing information.

Appended herewith are notes compiled by Dr. Snyder from 1909 to 1932.

Nacerda melanura, Linn. Family *Oedemeridae* "The Wharf Borer".

Denmark

J. C. Nielsen (Zoological Museum, Copenhagen) states in reply to a letter of inquiry that the larvae occur in most Danish harbors in bulwarks, also in sleepers in the free trade port. The lumber is treated with tar, creosote, zinc chloride, blue vitriol, and other metallic salts but is attacked after being in the water for some time, when the preservative has been washed out.

PHOTO No. 2.—Wharf Borer damage New York Dock Company, untreated pine pile, section above the water line.

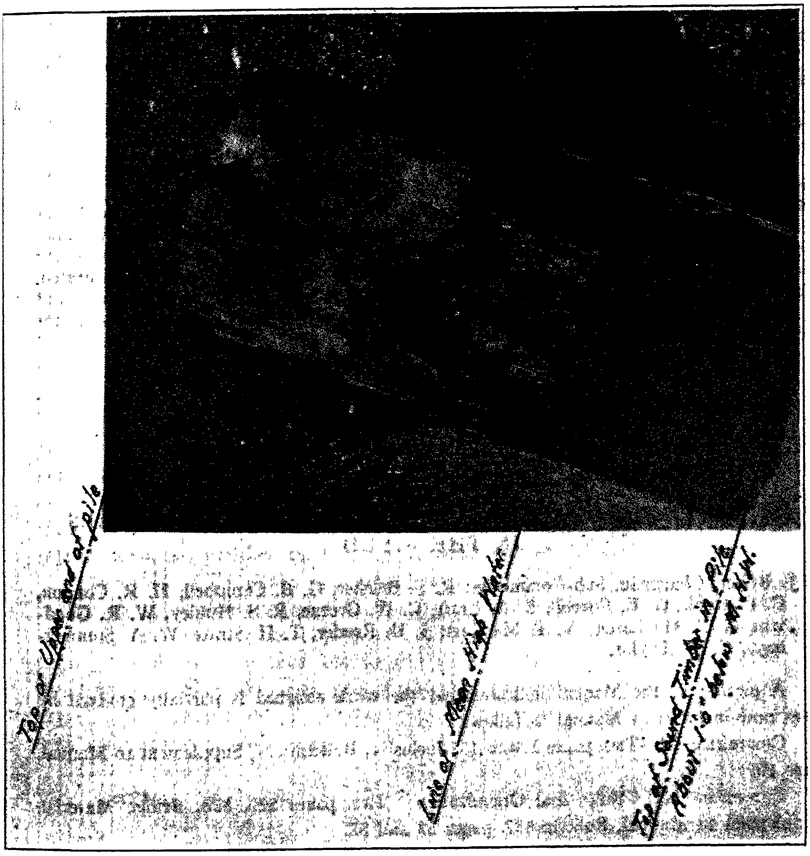


PHOTO No. 3.—Bearing Pile from Pier No. 24, New York Dock Company showing destruction by Wharf Borer in decayed portion.

New Zealand

Th. Brown—"Nacerda melanura Linn.—The Wharf Borer." 10th Rept. New Zealand Dept. Agr. 1902, pp. 460–2 (larva, pupa and adult figured in paving blocks and wharf timbers).

Bahamas

Leng and Mutchler—"A preliminary list of the Coleoptera of the West Indies is recorded to Jan. 1, 1914, Amer. Mus. Nat'l Hist. Bul. Vol. 33, New York, 1914 (p. 391–393, adult occurs).

United States

BALTIMORE, MD., Jan. 14, 1909—Larvae medium to large found in yellow pine timber sheet piling, just at the mud line at an elevation of 4 feet below mean low water. Had penetrated wood to depth from 1 inch to 1½ inches from surface.

NORFOLK, VA.—C. M. Kerr in April, 1930, reported damage by this borer to a creosoted conduit about 3 feet below the street level at the intersection of Granby and Tazewell Streets, about one block from the waterfront, but at times the spring tides accompanied by a northeast wind permits the water to seep through the ground at the level of the conduit.

NEW ORLEANS, LA., Feb. 1915—Larvae in creosoted pine piling (wharf) longleaf pine, 16 lb. English creosote per cubic foot, piles attacked at ground line-point, reached by high water in Mississippi 1912–13, not exposed since then; 25% piles attacked; piling been in place about 8 years. Piling was not in either salt or fresh water.

MAGAZINE POINT, ALA., Feb. 1915—Larvae in creosoted pine telephone pole (cylinder pressure process, 12 lbs. per cu. ft.) been set 16 years, Fall, 1899 to Feb. 1915.

BLOOMINGTON, GA., (near Savannah) Oct. 1915—Larvae in Southern white cedar telephone pole treated with 2 coats coal creosote—pole in ground 10 years. July, 1905 to Oct. 1915.

Dr. A. D. Hopkins has collected this species in driftwood along the seashore at Virginia Beach. H. E. Burke collected the adult at Des Moines, Washington on July 11, 1909, flying among driftwood on the beach at Puget Sound. H. S. Barber found larvae in decaying white pine flooring (ground floor) in a house building in N. E. Washington, D. C. E. A. Schwarz states that larvae occur in the wood at the bases of the telephone poles where dogs had urinated, also in the wood of fences similarly saturated. Wood wet with salt water or urine seems more liable to attack. Dr. A. E. Satterthwait reported finding adults at Sea Isle City, N. J. and more recently in buildings in the vicinity of St. Louis, Mo. (in May, 1930).

Conclusion

It is recommended that this report be accepted as information.

Appendix F

(6) METHODS OF PROTECTION OF TREATED MATERIALS IN THE FIELD

L. J. Reiser, Chairman, Sub-Committee; R. S. Belcher, G. B. Campbell, H. R. Condon, C. C. Cook, G. E. Cornell, E. A. Craft, C. W. Greene, R. S. Hubley, W. R. Goodwin, G. P. MacLaren, W. T. MacCart, J. H. Reeder, T. H. Strate, W. A. Summerhays, C. M. Taylor.

A perusal of the Manual indicates that the work assigned is partially covered by rules now included in Manual as follows:

Committee III—Ties, pages 130 to 132 inclusive, Bulletin 337, Supplement to Manual, page 10.

Committee XII—Rules and Organization: Ties, pages 827, 828, Bridge Material, Supplement to Manual, Bulletin 337, pages 82 and 83.

Committee XVII—Wood Preservation, pages 1275 to 1277 inclusive.

Owing to conditions which have prevailed during the past year, the work of the Sub-Committee has necessarily been conducted almost entirely by correspondence, and following rules are submitted as tentative report.

GENERAL STATEMENT

In treatment of ties and timber to prevent decay the life service to be obtained from proper treatment is largely dependent on adherence to definite rules in handling, care, and efficient use. Necessary precautions should, therefore, be observed to obtain maximum life service.

(1) Ties shipped from treating plant or storage yards must be loaded in accordance with M.C.B. Rules. To prevent loss or damage ties loaded in open top cars must be securely wired when necessary and stock or box cars should be sealed.

(2) Care should be exercised when unloading creosoted ties to avoid fracture and exposing untreated wood. They should not be thrown down high embankments or on rails, rocks, and other creosoted timbers which may be splintered or fractured. They should not be removed from cars with sharp pointed or edged tools.

(3) Where necessary to store ties on right-of-way, treated ties should be piled in solid piles (as specified in Manual, pages 130 and 131) to retard evaporation of the preservative, and prevent checking or warpage, except ties treated with zinc chloride or other water borne salts.

(4) Treated ties should not be stacked within fifty feet of overhead bridges, trestles, or buildings. They should be at least an equal distance from highway crossings and further where possible to discourage loss by theft or interference with view of enginemen and drivers of highway vehicles. They should not be stacked under telegraph, telephone, or signal wires, should conditions make such impractical, they should be stacked in small piles widely spaced as possible.

(5) Creosoted ties may be used as soon as received but it is recommended that they be held in closely stacked piles at least sixty days, during which time the creosote becomes congealed or viscous which contributes to better spiking conditions.

(6) Boring of ties results in increased penetration of the preservative surrounding spike area, and all adzed and bored ties must be spiked in the bored holes regardless of line end.

(7) Adzed and bored ties must be used with weight of rail for which prepared and spikes must be driven in the bored holes and not in solid timber. Careless spiking of bored ties will cause reduction of strength at or near spike holding area.

(8) Ties split or cracked where bored will cause spike holding power to be greatly impaired. It is, therefore, desirable to vary from standard practice in positioning of spike by reversing position where possible to avoid spiking in crack.

Use of plates with four spike slots with renewals or when regaging or rail relay operations will facilitate use of most desirable location with ties having such defects.

(9) The rail must be to gage with tie plates properly seated with firm and true bearing, shoulders to fit snug and parallel with base of rail. To avoid mutilation of wood fibers, bearing face of tie or location of plate should be cleaned of dirt, chat, or gravel, before placing plate in position, when holes in plates should be carefully aligned with holes in ties before spiking.

(10) In spiking bored ties it is important that spikes be started and driven vertically, square and snug against rail to obtain maximum spike hold in timber. Careless driving will result in mutilating fiber around spike hole, contributing to loose spikes with accumulative moisture and infection in untreated wood at center of tie.

(11) At locations where it is frequently necessary to clean ashpans, ties should be provided with covers of sheet metal. This covering should rest on furring, providing clearance of not less than one inch to prevent charring of ties.

(12) When making inspection of treated ties in track for renewals, they should not be tested or marked with pick or adze, or other sharp tools which may cut or puncture through to the untreated wood.

(13) Ties which have not been inserted and have suffered splitting or warping since treated or have such defects as to cause them to be of secondary quality should be used in sidings where more service may be obtained.

(14) Excessive checked or split ties should not be used at joints which may give more service elsewhere. Care should be exercised that ties be of such dimension and quality to insure maximum strength and service at this location.

(15) Ties when inserted should be firmly and fully tamped. When tamping ties in track the bed of neighboring ties should be disturbed as little as possible so that all may be left firmly and evenly bedded which contributes to uniform distribution of load and reducing plate wear in ties to minimum.

(16) Loose spikes indicate abnormal wear on walls of spike hole, contributing to easy access of water, thereby subjecting such area to decay. All such spikes should be withdrawn and creosoted tie plugs driven full length in hole and respiking into plug. Treated tie plugs should always be available as required to plug holes when respiking of standard dimensions as specified pages 132 and 133 in Manual.

(17) Treated ties bruised by derailments but still serviceable at location where damaged may be adzed to remove crushed fibers, such adzed surfaces to be protected by application of hot creosote oil. Ties damaged by derailment or on account of mechanical wear to such extent as to be unserviceable at that location should be salvaged for use in less important trackage or for other uses such as fencing, bulkheading, etc., according to their value.

(18) In removal of ties due to change of line, new switches, etc., they should be carefully inspected by Roadmaster or Track Inspector, and those suitable for further service retained for use in such tracks as may be warranted by their condition.

(19) In relaying of rail and tie plates where adzing of ties is necessary due to wear, ties should be adzed to depth of rail cut or wear in straight line across face parallel with rail, the length adzed to be governed by size of tie plate used. Before adzing all spike holes should be full driven with creosoted plugs and newly adzed surfaces well cleaned and given a thorough application of hot creosote.

(20) In disposing of worthless ties by burning, they should be burned at a sufficient distance to avoid scorching ties in track. They should not be burned near bridges, telegraph poles, newly creosoted ties, or other treated or combustible materials.

Treated Switch Ties

(1) The rules recommended for proper protection of cross-ties will also apply to switch ties.

(2) Care should be taken in ordering switch ties of proper length so that they may be placed in accordance with standard plan and prevent damage to treated wood by cutting back to lengths required.

(3) They should be stamped on end to indicate length which will facilitate distribution for insertion.

(4) Switch ties located in switches subjected to excessive operation should be of such quality to withstand the severe mechanical wear, especially turnouts in heavy switching yard leads. Untreated hardwood is recommended where such treated lengths require frequent renewal.

Treated Signal Timber and Trunking

(1) All timber should be cut to length and framed prior to treatment because cutting the material after treatment shortens its life. If it is necessary to cut any treated timber, it should be given at least two coats of hot creosote.

(2) Trunking and capping treated with creosote or other preservative should be stored under cover whenever practicable to prevent damage by splitting, excessive checking, or warping. If unable to store under cover, it should be close piled and covered with soil to retard evaporation of preservative and warpage of material at top of pile.

Treated Telegraph Poles

(1) To obtain maximum life service it is necessary to avoid gaining and boring of poles after treatment. They should be gained for cross arms, roofed, if specified, and all necessary holes bored prior to treatment as indicated by standard plan. All gains should be cut accurately and parallel so that cross arms will be in vertical alinement, thus eliminating any necessity of having to regain or bore into the treated wood.

(2) After treatment poles should be carefully handled so that treatment is not punctured by grab hooks or fractured by impact. When possible, poles should be unloaded by crane or derrick.

(3) All poles should have treatment of sufficient depth so that lineman's climbers will not penetrate through the treated wood which may cause infection and decay.

(4) Poles in service should have grass and weeds cleared over sufficient area to prevent burning or damage by excessive heat which would cause creosote to exude from pole when overheated.

(5) If necessary that any poles be framed or bored in the field, all newly framed or bored surfaces should be protected with application of hot creosote.

Conclusion

It is recommended that this report be accepted as information.

Appendix G

(7) DEVELOP SUITABLE TABLES OF FACTORS OF EXPANSION FOR COAL-TAR, PETROLEUM, CREOSOTE COAL-TAR SOLUTION AND CREOSOTE PETROLEUM MIXTURES FOR SUCH RANGES OF TEMPERATURE AS ARE OF INTEREST TO THE USERS OF TREATED TIMBER

E. B. Fulks, Chairman, Sub-Committee; L. H. Harper, H. E. Horrocks, M. F. Jaeger, F. D. Mattos, O. C. Steinmayer, L. B. Shipley.

Your Committee now reports that the Bureau of Standards and the cooperating committees have completed tables for making temperature corrections of volume and specific gravity for creosote, creosote coal-tar solution and coal tar. These tables have been approved for use by the American Society for Testing Materials and the American Wood Preservers' Association and have been presented by the Sub-Committee on Revision of Manual for adoption by the American Railway Engineering Association as noted in Appendix A.

Conclusion

The Committee feels that as it has carried out work prescribed for it that this report should be accepted and the subject discontinued.

REPORT OF COMMITTEE V—TRACK

C. R. Harding, *Chairman;*
C. A. Alden,
W. G. Arn,
W. H. Bettis,
W. H. Bevan,
L. H. Bond,
R. W. E. Bowler,
C. W. Breed,
H. W. Brown,
W. G. Brown,
E. W. Caruthers,
H. R. Clarke,
J. E. Deckert,
J. W. DeMoyer,
L. W. DesLauriers,
J. J. Desmond,
J. A. Ellis,
F. W. Gardiner,
F. S. Hales,
W. J. Harris,
O. F. Harting,
F. W. Hillman,
J. E. Hogan,
E. T. Howson,
W. G. Hulbert,
T. T. Irving,
F. J. Jerome,
H. D. Knecht,
J. de N. Macomb,
F. H. Masters,
C. M. McVay,
J. C. Mock,
J. B. Myers,
A. J. Neafie,
J. V. Neubert,
G. A. Peabody,
O. C. Rehfuss,
C. J. Geyer, *Vice-Chairman;*
C. J. Rist,
W. L. Roller,
E. M. T. Ryder,
I. H. Schram,
G. L. Sitton,
G. J. Slibeck,
G. L. G. Smith,
Theo. Speiden, Jr.,
H. C. Stiff,
G. M. Strachan,
C. R. Strattman,
J. B. Strong,
E. D. Swift,
T. P. Warren,
J. R. Watt,
H. N. West,
J. G. Wishart,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents reports on the subjects assigned, as follows:

(1) Revision of Manual (Appendix A).

(1-A) Specifications for soft steel track spikes (Appendix B).

(2) String lining of curves by the chord method, and preparation of tables suitable for the use of trackmen (Appendix C).

(3) Plans and specifications for track tools, collaborating with Committees I—Roadway, II—Ballast, and XXII—Economics of Railway Labor (Appendix D).

(4) Plans for switches, frogs, crossings, slip switches, etc., (Appendix E).

(5) Track construction in paved streets, collaborating with Committee IX—Grade Crossings (Appendix F).

(6) Corrosion of rail and fastenings in tunnels, collaborating with Committee IV—Rail (Appendix G).

(7) Gage of track and elevation of curves with reference to the use of roller bearings on railway equipment, collaborating with the Mechanical Division of the A.R.A., (Appendix H).

(8) Effect of existing materials in track on the design of tie plates and punching thereof, together with the interrelation of slotting of joint bars and size of track spikes, collaborating with Committee IV—Rail (Appendix I).

(9) Practicability of using "Reflex" units for switch lamps and targets, collaborating with Committee X—Signals and Interlocking (Appendix J).

(10) Selective welding up at joints, instead of welding out of face (Appendix K).

(11) Desirable tightness of track joints and effect upon the life of rails and joints of overtight joints; of loose joints (Appendix L).

(12) Reclamation of serviceable materials from scrap and retired maintenance of way and structure machines, tools and appliances, collaborating with Division VI—Purchases and Stores, A.R.A. (Appendix M).

(13) Standard wheel flanges, treads and gages, collaborating with the Mechanical Division of the A.R.A. and the Association of Manufacturers of Chilled Car Wheels (Appendix N).

(14) Damage from brine drippings, collaborating with the Mechanical Division of the A.R.A. (Appendix O).

Bulletin 352, December, 1932.

Action Recommended

(1) That revisions recommended in Appendix A be approved for publication in the Manual.

(2) That Plan No. 11 in Appendix D be adopted as recommended practice and published in the Manual, replacing Plan No. 11, dated September, 1929, adopted in 1930.

(3) That Plan No. 600-A in Appendix E be adopted as recommended practice and published in the Manual, and that the recommendation in Appendix E for the drilling and finishing of bolt holes in switch points made of rolled manganese steel rails be received as information.

(4) That Plan No. 790 in Appendix N be adopted as recommended practice and published in the Manual.

(5) That Plans Nos. 987 and 988 in Appendix F be adopted as recommended practice and published in the Manual.

(6) That the report in Appendix C be received as information.

(7) That the report in Appendix H be received as information.

(8) That the report in Appendix J be received as information.

(9) That the report in Appendix K be received as information.

(10) That the report in Appendix O be received as information.

(11) That progress reports in Appendices B (Item 1-A), G, I, L and M, be received as information.

Respectfully submitted,

THE COMMITTEE ON TRACK,

C. R. HARDING, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

C. R. Harding, Chairman, Sub-Committee; C. J. Geyer.

The Committee recommends the revision of the Index and Index Supplement to the A.R.E.A. Trackwork Plans and Specifications, pages 1, 2, 3 and 4 dated 1932 by the substitution of a revised Index and Index Supplement dated 1933, pages 1, 2, 3, 4, 5 and 6, listing existent plans and specifications and including the new plans presented herewith.

Pages 4, 5 and 6 (the Index Supplement) describe revisions to the plans which are identified on Index pages 1, 2 and 3 by the letter "x" following the serial number.

The revisions of the Index Supplement consist of the following additions:

Notes for plans of frogs, crossings and guard rails to make said plans consistent with Plan No. 790, which is now being offered for recommended practice in Appendix (N) and shows a standard width of flangeway of 1⅞"; Plan No. 790 also makes necessary a revision of paragraph 33 of Appendix (B) and of the definition "Flangeway Width" in Appendix (C) of the A.R.E.A. Specifications for Switches, Frogs, Crossings and Guard Rails.

Notes for plans of manganese steel frogs, railbound, solid and self-guarded, for laying out flangeways wider than 1¾".

Notes for other plans to make them consistent with recently adopted plans and to make minor corrections.

Attention is also called to revision in length of tongue switches for paved streets, as specified in revised index supplement in reference to Plans 980 and 982.

The Committee also recommends that Plan No. 11—Claw Bar, adopted by the Association in 1930, be withdrawn from the Manual and that Plan No. 11, dated September 1932, be substituted therefor. The new plan does not change the Claw Bar now appearing in the Manual, but does show an alternate in addition to the approved design.

Appendix B

(1-A) SPECIFICATIONS FOR SOFT STEEL TRACK SPIKES

E. D. Swift, Chairman, Sub-Committee; R. W. E. Bowler, J. E. Deckert, C. J. Geyer, C. R. Harding, F. J. Jerome, J. de N. Macomb, J. V. Neubert, G. L. Sitton, G. L. G. Smith.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year, and it is recommended that the subject be continued.

Appendix C

(2) STRING LINING OF CURVES BY THE CHORD METHOD AND PREPARATION OF TABLES SUITABLE FOR THE USE OF TRACKMEN

C. W. Breed, Chairman, Sub-Committee; W. H. Bettis, L. H. Bond, C. J. Geyer, F. S. Hales, C. R. Harding, J. E. Hogan, E. T. Howson, C. M. McVay, C. R. Strattman, T. P. Warren.

The Committee submits the following report as information, and it is recommended that the subject be continued.

STRING LINING OF CURVES BY THE CHORD METHOD WITH TABLES SUITABLE FOR THE USE OF TRACKMEN

String lining of curves may be used advantageously to supplement the Engineer's transit. Briefly, the method consists in dividing the curve to be lined into 31 foot stations, recording the mid-ordinates of chords spanning each two stations and laying out a reasonable amount of throw, if necessary, at each station. No rule can be laid down to insure a satisfactory realignment at the first trial. At best, this is a cut and try method with sufficient definite rules and instructions to enable the user to lay out throws at each station throughout the curve that will give an alignment, if the work is carefully done, approaching transit survey accuracy.

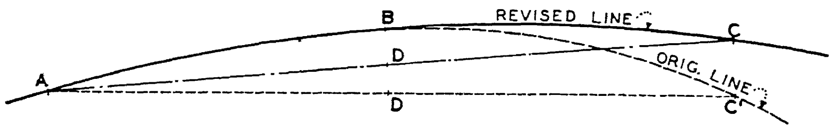
Any number of combinations of throws with balanced results may be obtained—some bad and others good—so that the work should be placed in the hands of a person with dependable judgment. Such person should also have at least one year of High School algebra and one year's experience in survey measurements.

The purpose is to secure an alignment in which the ordinates at each station are as nearly uniform as possible. A considerable difference in the ordinates of the circular curve must be carefully avoided in the interest of easy riding and safe track.

String lining is based on the following principles: The mid-ordinates of a circular curve are indicative of its degree of curvature. Hence, the ordinates of a circular curve are equal for a chord of uniform length. The ordinate of a spiral curve will vary in accordance with a specified progression.

The angle between tangents is the sum of the angles subtended by the chords of the curve. For all practical purposes, on curves of more than 193 foot radius (less than 30° curvature) the mid-ordinate of a given length of chord varies directly with the degree of curvature, or, in other words, varies directly with the subtended angle. Hence, the sum of the mid-ordinates is a measure of the angle between tangents. Since it is not the purpose of string lining to change the angle between tangents but merely to restore the curve to one having uniform properties: ***The sum of the mid-ordinates before lining must equal the sum of the mid-ordinates of the realigned curve.***

The throw at any station on a curve will change the ordinate at that point by an amount equal to the throw and will increase or decrease the ordinates at adjacent stations by an amount equal to one-half the throw, always increasing when the throw decreases and decreasing when the throw increases the ordinate.



$AD = \frac{AC}{2}$ Therefore, $DD' = \frac{CC'}{2}$ *The throw at C is CC'*; the mid-ordinate at B has been reduced by DD'.

General Instructions for Field Work

Tools Required

100 ft. strong fish line.
50 ft. steel tape.
Marking crayon.
A suitable rule graduated to inches and tenths with graduations beginning at extreme end of scale.
Note book.
Pad of forms (described later).
Table of ordinates.

All work is done on the outside rail of the curve. First stand on tangent several rail lengths back from the curve and locate the beginning of the curve as closely as possible by eye. This point is Station Zero and should be marked. The station 31 feet back along the tangent is Station —31.

Beginning at Station —31, lay off with steel tape and mark each 31 foot point and number consecutively as Station —31, 0, 1, 2, 3, etc., and continue the stationing at least two stations beyond the point of tangent, which is also located by eye. These station numbers are entered in Column 1 of sample form.

Beginning at Station Zero, measure the mid-ordinate in tenths of inches from the outside rail to the line joining Stations —31 and 1. This is entered in Column 2 of the sample form. Proceed around the curve to the P.T. measuring the mid-ordinate at each station and entering on the form.

Take track centers at frequent intervals where there is more than one track, and record any obstacle which might affect lining. If more than one track is to be lined, measure the mid-ordinates on each track.

The form shown in the example was developed so that several corrections might be made without necessity of erasures.

Column 1 is for station numbers.
Column 2 is for measured mid-ordinates in tenths of inches.
Column 3 is for revised mid-ordinates and is divided into sub-columns for convenient changes.
Column 4 is for difference between ordinates in Columns 2 and 3.
Columns 5 and 6 are explained by headings. The operation in each column is shown by arrows on example.

The method of obtaining Revised Ordinates was chosen for its feasibility in determining a good realignment which will require a minimum amount of throw. The Revised Ordinates are entered in Column 3.

The table of ordinates made a part of this method was so calculated that each 31 foot station on the spiral falls exactly to the nearest tenth of an inch on a spiral calculated by the same method as is used in calculating the AREA 10-chord spiral. Frequently the use of the ordinates first selected will require too much throw. Another set of adjacent ordinates should be tried, and if these fail to give the desired results spiral and curve ordinates interpolated between the two may be used. A little practice will enable the user to select the best set of ordinates.

By inspection of Measured Ordinates in Column 2, the beginning and ending of spiral curves is located as nearly correct as possible.

In the example shown, the end of the first spiral is taken to fall at Station 7. It should be noted at this point that the exact location of the beginning and ending of spiral is not important as the variation in mid-ordinates at the end of the spiral automatically adjusts the ends. Find the sum of the ordinates up to and including Station 7. This sum is found to be 191. Referring to the table headed "Mid-Ordinates for Spiral 217 ft. long (7 Stations)", a spiral with a sum of ordinates of 191 is seen to lie between a 4°–40′ and a 4°–50′ curve. Trying the flatter curve first, the spiral ordinates 1, 7, 13, 20, 27, 34, 40 and 46 are entered in sub-column "A" under "Revised Ordinates" and the ordinate of the circular curve, 47, is carried out to Station 11.

In Column 4 are entered the differences between the measured ordinate, Column 2, and the revised ordinate, Column 3. If the ordinate in Column 3 at any station is larger than that in Column 2, the sign of the difference in Column 4 is minus. Conversely, if the revised ordinate is less than the measured ordinate the sign of the difference is plus.

In Column 5 are entered the algebraic sums of the differences (shown in Column 4) up to and including the stations being entered. The operation is performed in sequence as indicated by arrows.

In Column 6 the Half Throw is entered. The result shown here is the algebraic sum of Column 5 up to and including the preceding station. The operation is also performed in order as shown by arrows.

Computations carried through to Column 6 in the example indicate a half-throw of —31, or a Full Throw of 6.2 in. at Station 7, which is too great, and the indications are that this negative throw will continue to increase. The minus sign of the Half Throw indicates that ordinates slightly smaller should be selected. The 7 Station table is again referred to and the spiral ordinates for a 4°–30′ curve, 1, 6, 13, 19, 26, 32, 39 and 44 are entered in sub-column "B" and the curve ordinate of 45 carried out through Station 11. Computing again through to Column 6, we have a Half Throw of plus 29 at Station 11. This is too great a throw in the positive direction.

Interpolating a spiral between those used in sub-columns "A" and "B", the spiral ordinates for a 4°–35′ curve are set down in sub-column "C" and the curve ordinate of 46 is carried out a few stations below the S.C. at Station 7. Computing a third time through to Column 6 the Half Throw at Station 7 is —26 and at Station 11 is —10 which gives a practical throw. For trial the circular curve ordinate of 46 in Column 3 is carried through to Station 23 (one station back of the circular curve from the C.S.) and the extensions made to Column 6 where the half-throw is plus 31.

Sum up the measured ordinates in Column 2 from Stations 24 to 32, both inclusive. These, by inspection, are the ordinates on the spiral and total 190. To assure that Column 5 will end in 0 the sum of differences (+1) must be deducted from the sum of measured ordinates leaving 189. In the table of 7 Station Spirals, the sum of ordinates for a 4°–40′ curve is 186, or 1 less than the required amount. As this spiral is sufficiently close to the required one of 4°–35′, the ordinates shown in the table are entered in sub-column "B" under Revised Ordinates, increasing Station 29 from 13 to 14 to provide a sum of ordinates of 189.

Carrying the calculations through to Column 6, the sum of differences checks out zero, but the final Half Throw is +17. As both Columns 5 and 6 must balance out zero an adjustment of the revised ordinates is necessary and is made according to the following rule:

> When the final Half Throw is positive subtract from the revised ordinates having high station numbers and add an equal amount to the ordinates having low station numbers, choosing stations in pairs such that the sum of the differences of the station numbers, taken in pairs, equals the numerical amount of the final Half Throw. When the final Half Throw is negative, reverse the procedure, subtracting from the ordinates having low station numbers and adding to those having high station numbers.

Since in the example the final Half Throw is +17 an ordinate (or ordinates) of a low station will have to be increased and of a high station decreased. As it is desirable to keep the spiral uniform, let us change Station 24 from 47 to 46 and Station 22 from 46 to 47. This change will decrease the final Half Throw by 2 = 1 × (Sta. 24 — Sta. 22). Let us now change Station 29 from ordinate 14 to ordinate 13, the ordinate shown in the table. Then following the rule, subtract (17 — 2 = 15) from the Station Number (29) leaving 14 and increase the ordinate at Station 14 from 46 to 47. These revised ordinates are entered in sub-column "D". Carrying out the calculations again to Column 6, the final Half Throw becomes 0 and the ordinates are balanced. It is also to be noted that these changes have brought the Half Throw at Station 20 from 33 down to 27, a very desirable result.

Another method for obtaining the ordinates of the spiral from the table is to average the ordinates of the circular curve. In the example, this average is 46.3. The curve having an ordinate of 46.3 is 4°–37.8′ and spirals for 4°–30′ and 4°–40′ as well as spirals interpolated between these two could be used, selecting such length of spirals as would give approximately the sum of ordinates as given by the sum of measured ordinates.

The solution of compound curves by string lining is relatively simple. If the two branches of the curve are connected by a spiral whose mid-ordinates increase (or decrease) uniformly from the mid-ordinate of the first circular curve to the mid-ordinate of the second circular curve, the spiral will correspond to a curve calculated on the same basis as the AREA 10-chord spiral. The mid-ordinates at the points of curve-spiral (C.S.) and spiral-curve (S.C.) must be decreased or increased according to the following rule:

In laying out a spiral between curves, subtract the mid-ordinate of the flatter curve from the mid-ordinate of the sharper curve and divide the difference by the number of station lengths in the spiral calling the result "D". Starting at the end of the spiral next the flatter curve, the mid-ordinate of the first spiral station will be the mid-ordinate of the flatter curve plus D; of the second spiral station will be the mid-ordinate of the flatter curve plus 2D; and so on to the last station on the spiral. The mid-ordinate of the point of spiral-curve at the flatter end of the spiral will be the mid-ordinate of the flatter curve plus ⅙ D; the mid-ordinate of the point of spiral-curve at the sharper end of the spiral will be the mid-ordinate of the sharper curve less ⅙ D.

Thus if we have a curve with mid-ordinate 24 at Station 12 to connect with a curve of mid-ordinate 45 at Station 16, the curve and spiral ordinates will be as follows:

Station	*Mid-Ordinates*
11	24
12 P.C.S.	$25 = 24 + \frac{1}{6}\left(\frac{45-24}{4}\right)$
13	$29 = 24 + \frac{45-24}{4}$
14	$34 = 24 + 2 \times \frac{45-24}{4}$
15	$40 = 24 + 3 \times \frac{45-24}{4}$
16 P.S.C.	$44 = 45 - \frac{1}{6}\left(\frac{45-24}{4}\right)$
17	45

In working out string line problems considerable assistance can be gained by plotting out the measured mid-ordinates against the station numbers. The accompanying chart shows the result for the example given. By plotting out the mid-ordinates in this manner, the ends of the spiral as well as any points of compounding can be determined very readily and an estimate of the average ordinate to use on the circular curve section can be quite closely determined.

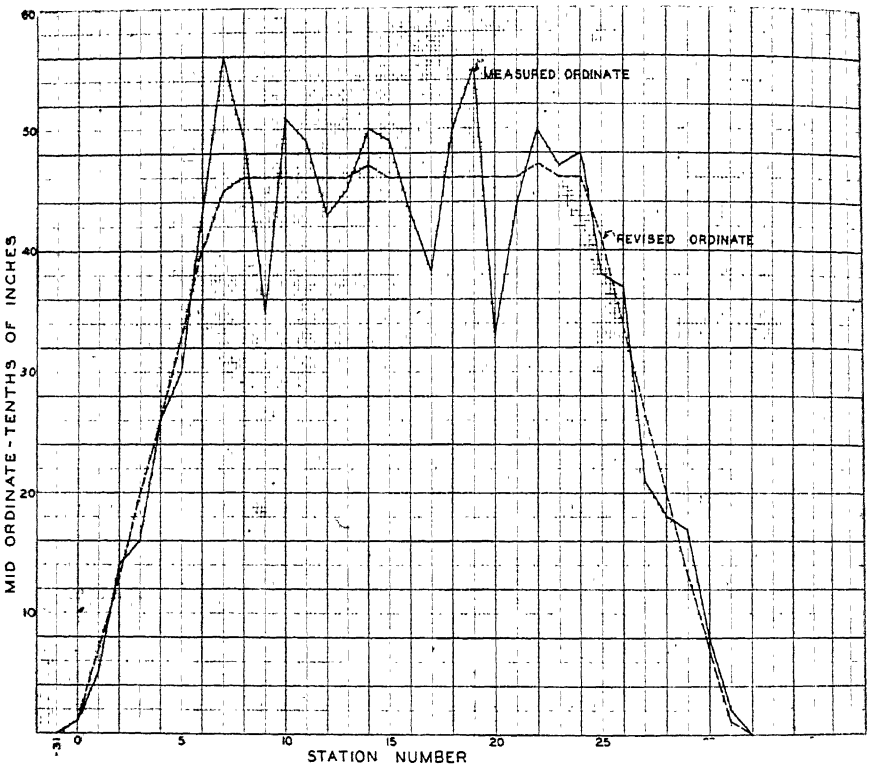
As stated above, there is a possibility for any number of solutions and considerable judgment must be exercised. Recommendation is made that the user be limited in amount of permissible throw. Many things may govern the final selection of a solution —width of ballast, width of roadbed, bridges, interlocking, and other physical conditions.

Usually a throw in excess of six inches will not be desirable.

In connection with Column 6, it is to be noted that a negative half-throw means that the track at the station is to be thrown in, while a positive half-throw means the track is to be thrown out. The full-throw is, of course, twice the half-throw.

Column 7 of the sample form is for use in setting center line stakes and gives the distance at each station from the gage side of the outside rail to the revised center line of track at each station. The figures in this column are obtained by subtracting algebraically the Full Throw (twice the final figures in Colunm 6) from one-half the gage, or 28.25″.

Column 8 is for listing any notes which may affect the lining of the curve.


MEASURED ORDINATE
REVISED ORDINATE
MID ORDINATE - TENTHS OF INCHES
60
50
40
30
20
10
0
5
10
15
20
25
STATION NUMBER

	STA. No. (1)	ORDINATE Measured (2)	ORDINATE Revised (3)				DIFFERENCE (Col.2 - Col.3) (4)				SUM OF DIFFERENCES (Up to and Including the Station) (5)				HALF THROW (Sum Col.5 up to and including Preceding Station) (6)				TACK TO GAUGE (7)	REMARKS (8)
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D		
	-31	0	0	0	0		0	0	0		0	0	0		0	0	0		28.25"	
T.S.	0	1	1	1	1		0	0	0		0	0	0		0	0	0		28.25"	
	1	5	7	6	7		-2	-1	-2		-2	-1	-2		0	0	0		28.25"	
	2	14	13	13	13		+1	1	1		-1	0	-1		-2	-1	-2		28.65"	
	3	16	20	19	20		-4	-3	-4		-5	-3	-5		-3	-1	-3		28.85"	
	4	26	27	26	26		-1	0	0		-6	-3	-5		-8	-4	-8		29.85"	
	5	30	34	32	33		-4	-2	-3		-10	-5	-8		-14	-7	-13		30.85"	
	6	43	40	39	40		+3	+4	+3		-7	-1	-5		-24	-12	-21		32.45"	
S.C.	7	56	46	44	45		+10	+12	+11		+3	+11	+6		-31	-13	-26		33.45"	
	8	49	47	45	46		+2	+4	+3		+5	+15	+9			-2	-20		32.25"	
	9	35	47	45	46		-12	-10	-11		-7	+5	-2			+13	-11		30.45"	
	10	51	47	45	46		+4	+6	+5		-3	+11	+8			+18	-13		30.65"	
	11	49	47	45	46		+2	+4	+3		-1	+15	+6			+29	-10		30.25"	
	12	43			46				-3				+3			+44	-4		29.05"	
	13	45			46				-1				+2				-1		28.45"	
	14	50			46	47			+4	+3			+6	+5			+1	+1	28.05"	
	15	49			46				+3				+9	+8			+7	+6	27.05"	
	16	43			46				-3				+6	+5			+16	+14	25.45"	
	17	38			46				-8				-2	-3			+22	+19	24.45"	
	18	50			46				+4				+2	+1			+20	+16	25.05"	
	19	55			46				+9				+11	+10			+22	+17	24.85"	
	20	33			46				-13				-2	-3			+33	+27	22.85"	
	21	44			46				-2				-4	-5			+31	+24	23.45"	
	22	50			46	47			+4	+3			0	-2			+27	+19	24.45"	
	23	47			46				+1				+1	-1			+27	+17	24.85"	
C.S.	24	48			47	46			+1	+2			+2	+1			+28	+16	25.05"	
	25	38			41				-3				-1	-2			+30	+17	24.85"	
	26	37			34				+3				+2	+1			+29	+15	25.25"	
	27	21			27				-6				-4	-5			+31	+16	25.05"	
	28	18			20				-2				-6	-7			+27	+11	26.05"	
	29	17			14	13			+3	+4			-3	-3			+21	+4	27.45"	
	30	9			7				+2				-1	-1			+18	+1	28.05"	
S.T.	31	2			1				+1				0	0			+17	0	28.25"	
	32	0			0				0											
	SUM	1112				1112														

EXPLANATION OF TABLES

The following tables present ordinates for spiral curves for every 10′ of degree of circular curvature from 1° to curves of degrees requiring 8″ of superelevation. The lengths of the spirals are from 155′ to 403′ and are graduated by even 31′ lengths.

Ordinates are given at the point tangent to spiral and at every station 31′ apart throughout the length of the spiral. The last station shown in each table is the point of spiral-curve. The ordinates are to the mid-point of chords terminating at every other station.

The first column shows the degree of circular curve; the second column gives its ordinate. The ordinates are given in inches expressed in inches and tenths nearest the exact ordinate. The last column gives the sum of the ordinates from the tangent to and including the point of spiral-curve. This sum is a function of the angle traversed.

The AREA spiral resembles a curve whose radius at any point is inversely proportional to the length of arc from the origin to that point. At the end of the spiral the radius of the spiral is identical with that of the circular curve with which it is used.

While the following tables are convenient in working out string line problems their use is not absolutely necessary as a spiral corresponding exactly to an AREA spiral can be figured out very simply for any circular curve. The calculations involved, which are those used in computing the tables, are as follows:

Let M = Mid-ordinate of circular curve for a 62′ chord. For all curves less than about 30° curvature this mid-ordinate in inches is equal to the degree of curvature expressed in degrees. Thus a 4°–25′ curve has a mid-ordinate of 4.417″.

M_o = Mid-ordinate at point of spiral.

M_1 = Mid-ordinate at Station 1.

M_2 = Mid-ordinate at Station 2.

M_n = Mid-ordinate at point of spiral curve.

N = Number of stations on spiral. It is assumed that spiral is an even length in stations; that is, that the point of spiral-curve falls exactly on a station.

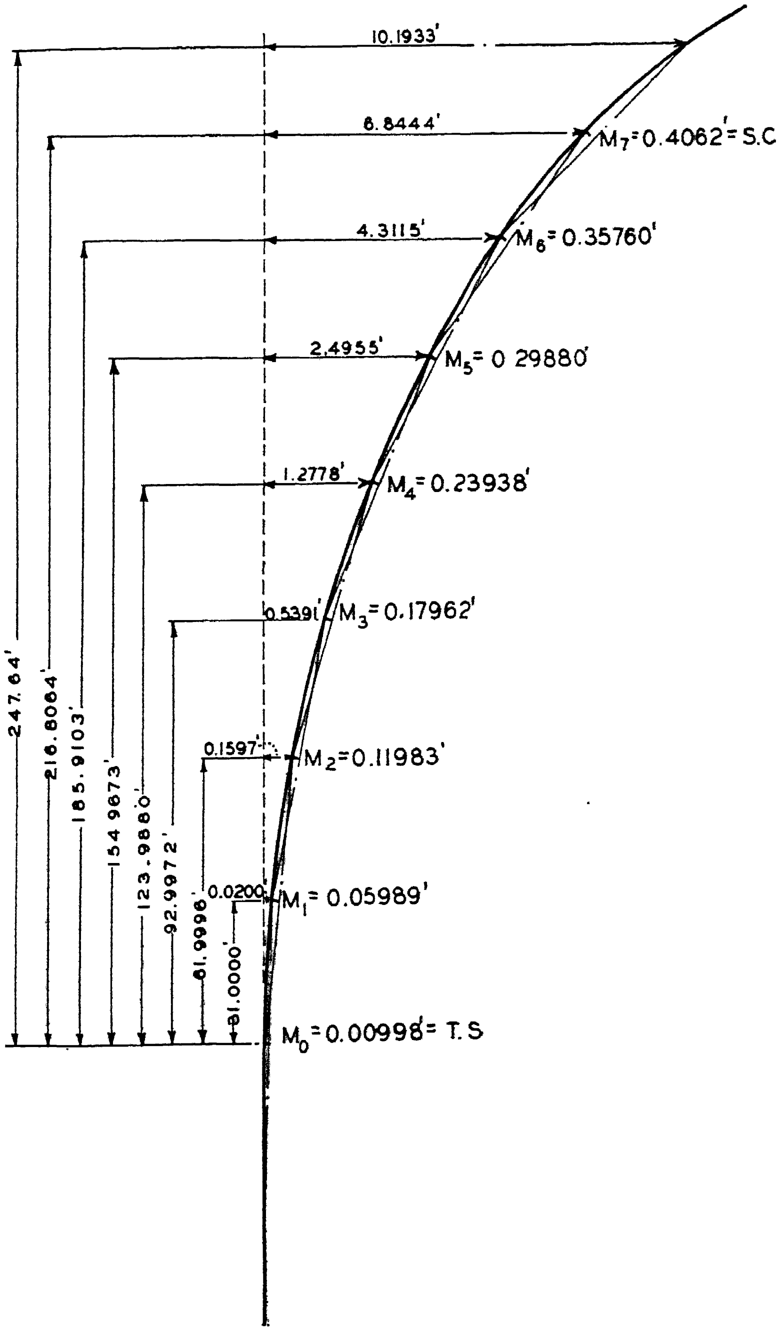
L = Length of spiral.

Then the following formulae can be proven true:

$$L = 31 \times N$$
$$M_1 = \frac{M}{N}$$
$$M_2 = 2M_1$$
$$M_3 = 3M_1$$
$$M_o = \tfrac{1}{6}M_1$$
$$M_n = M - M_o = M - \tfrac{1}{6}M_1$$

Thus if there are seven stations on the spiral, for example, and the circular curve has an ordinate of 5.0″, then

$$M_o = \tfrac{1}{6}\,\frac{5.0}{7} = 0.12''$$
$$M_1 = \frac{5.0}{7} = 0.7143''$$
$$M_2 = 2M_1 = 1.43''$$
$$M_3 = 3M_1 = 2.14''$$
$$M_4 = 4M_1 = 2.86''$$
$$M_5 = 5M_1 = 3.57''$$
$$M_6 = 6M_1 = 4.29''$$
$$M_7 = 5.0 - \tfrac{1}{6}\,\frac{5.0}{7} = 4.88''$$


10.1933'
6.8444'
M7=0.4062'=S.C
4.3115'
M6=0.35760'
2.4955'
M5=0 29880'
1.2778'
M4=0.23938'
0.5391'
M3=0.17962'
0.1597'
M2=0.11983'
0.0200
M1=0.05989'
M0=0.00998'=T.S
247.64'
216.8064'
185.9103'
154 9673'
123.9880'
92.9972'
61.9996'
31.0000'

MID-ORDINATES FOR SPIRAL 155' Long (5 Stations)

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral: Zero (T.S.)	1	2	3	4	5 (S.C.)	Sum of Ordinates
1°-00'	1.0	0.0	0.2	0.4	0.6	0.8	1.0	3.0
-10'	1.2	0.0	0.2	0.5	0.7	0.9	1.2	3.5
-20'	1.3	0.0	0.3	0.5	0.8	1.1	1.3	4.0
-30'	1.5	0.0	0.3	0.6	0.9	1.2	1.5	4.5
-40'	1.7	0.1	0.3	0.7	1.0	1.3	1.6	5.0
-50'	1.8	0.1	0.4	0.7	1.1	1.5	1.7	5.5
2°-00'	2.0	0.1	0.4	0.8	1.2	1.6	1.9	6.0
10'	2.2	0.1	0.4	0.9	1.3	1.7	2.1	6.5
20'	2.3	0.1	0.5	0.9	1.4	1.9	2.2	7.0
30'	2.5	0.1	0.5	1.0	1.5	2.0	2.4	7.5
40'	2.7	0.1	0.5	1.1	1.6	2.1	2.6	8.0
50'	2.8	0.1	0.6	1.1	1.7	2.3	2.7	8.5
3°-00'	3.0	0.1	0.6	1.2	1.8	2.4	2.9	9.0
10'	3.2	0.1	0.6	1.3	1.9	2.5	3.1	9.5
20'	3.3	0.1	0.7	1.3	2.0	2.7	3.2	10.0
30'	3.5	0.1	0.7	1.4	2.1	2.8	3.4	10.5
40'	3.7	0.1	0.7	1.5	2.2	2.9	3.6	11.0
50'	3.8	0.1	0.8	1.5	2.3	3.1	3.7	11.5
4°-00'	4.0	0.1	0.8	1.6	2.4	3.2	3.9	12.0
10'	4.2	0.1	0.8	1.7	2.5	3.3	4.1	12.5
20'	4.3	0.1	0.9	1.7	2.6	3.5	4.2	13.0
30'	4.5	0.2	0.9	1.8	2.7	3.6	4.3	13.5
40'	4.7	0.2	0.9	1.9	2.8	3.7	4.5	14.0
50'	4.8	0.2	1.0	1.9	2.9	3.9	4.6	14.5
5°-00'	5.0	0.2	1.0	2.0	3.0	4.0	4.8	15.0
10'	5.2	0.2	1.0	2.1	3.1	4.1	5.0	15.5
20'	5.3	0.2	1.1	211	3.2	4.3	5.1	16.0
30'	5.5	0.2	1.1	2.2	3.3	4.4	5.3	16.5
40'	5.7	0.2	1.1	2.3	3.4	4.5	5.5	17.0
50'	5.8	0.2	1.2	2.3	3.5	4.7	5.6	17.5
6°-00'	6.0	0.2	1.2	2.4	3.6	4.8	5.8	18.0
10'	6.2	0.2	1.2	2.5	3.7	4.9	6.0	18.5
20'	6.3	0.2	1.3	2.5	3.8	5.1	6.1	19.0
30'	6.5	0.2	1.3	2.6	3.9	5.2	6.3	19.5
40'	6.7	0.2	1.3	2.7	4.0	5.3	6.5	20.0
50'	6.8	0.2	1.4	2.7	4.1	5.5	6.6	20.5
7°-00'	7.0	0.2	1.4	2.8	4.2	5.6	6.8	21.0
10'	7.2	0.2	1.4	2.9	4.3	5.7	7.0	21.5
20'	7.3	0.2	1.5	2.9	4.4	5.9	7.1	22.0
30'	7.5	0.2	1.5	3.0	4.5	6.0	7.3	22.5
40'	7.7	0.3	1.5	3.1	4.6	6.1	7.4	23.0
50'	7.8	0.3	1.6	3.1	4.7	6.3	7.5	23.5
8°-00'	8.0	0.3	1.6	3.2	4.8	6.4	7.7	24.0
10'	8.2	0.3	1.6	3.3	4.9	6.5	7.9	24.5
20'	8.3	0.3	1.7	3.3	5.0	6.7	8.0	25.0
30'	8.5	0.3	1.7	3.4	5.1	6.8	8.2	25.5
40'	8.7	0.3	1.7	3.5	5.2	6.9	8.4	26.0
50'	8.8	0.3	1.8	3.5	5.3	7.1	8.5	26.5
9°-00'	9.0	0.3	1.8	3.6	5.4	7.2	8.7	27.0
-10'	9.2	0.3	1.8	3.7	5.5	7.3	8.9	27.5
-20'	9.3	0.3	1.9	3.7	5.6	7.5	9.0	28.0
-30'	9.5	0.3	1.9	3.8	5.7	7.6	9.2	28.5
-40'	9.7	0.3	1.9	3.9	5.8	7.7	9.4	29.0
-50'	9.8	0.3	2.0	3.9	5.9	7.9	9.5	29.5
10°-00'	10.0	0.3	2.0	4.0	6.0	8.0	9.7	30.0
-10'	10.2	0.3	2.0	4.1	6.1	8.1	9.9	30.5
-20'	10.3	0.3	2.1	4.1	6.2	8.3	10.0	31.0
-30'	10.5	0.4	2.1	4.2	6.3	8.4	10.1	31.5
-40'	10.7	0.4	2.1	4.3	6.4	8.5	10.3	32.0
-50'	10.8	0.4	2.2	4.3	6.5	8.7	10.4	32.5
11°-00'	11.0	0.4	2.2	4.4	6.6	8.8	10.6	33.0
-10'	11.2	0.4	2.2	4.5	6.7	8.9	10.8	33.5
-20'	11.3	0.4	2.3	4.5	6.8	9.1	10.9	34.0
-30'	11.5	0.4	2.3	4.6	6.9	9.2	11.1	34.5
-40'	11.7	0.4	2.3	4.7	7.0	9.3	11.3	35.0
-50'	11.8	0.4	2.4	4.7	7.1	9.5	11.4	35.5
12°-00'	12.0	0.4	2.4	4.8	7.2	9.6	11.6	36.0

MID-ORDINATES FOR SPIRAL 186' LONG (6 STATIONS)

Degree of Circular Curve	Ordinates of Circular Curve	Stations on Spiral: Zero (T.S.)	1	2	3	4	5	6 (S.C.)	Sum of Ordinates
1°-00'	1.0	0.0	0.2	0.3	0.5	0.7	0.8	1.0	3.5
-10'	1.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2	4.2
-20'	1.3	0.0	0.2	0.4	0.7	0.9	1.1	1.3	4.6
-30'	1.5	0.0	0.2	0.5	0.8	1.0	1.2	1.5	5.2
-40'	1.7	0.0	0.3	0.6	0.8	1.1	1.4	1.7	5.9
-50'	1.8	0.1	0.3	0.6	0.9	1.2	1.5	1.7	6.3
2°-00'	2.0	0.1	0.3	0.7	1.0	1.3	1.7	1.9	7.0
-10'	2.2	0.1	0.4	0.7	1.1	1.4	1.8	2.1	7.6
-20'	2.3	0.1	0.4	0.8	1.2	1.6	1.9	2.2	8.2
-30'	2.5	0.1	0.4	0.8	1.2	1.7	2.1	2.4	8.7
-40'	2.7	0.1	0.4	0.9	1.3	1.8	2.2	2.6	9.3
-50'	2.8	0.1	0.5	0.9	1.4	1.9	2.4	2.7	9.9
3°-00'	3.0	0.1	0.5	1.0	1.5	2.0	2.5	2.9	10.5
-10'	3.2	0.1	0.5	1.1	1.6	2.1	2.6	3.1	11.1
-20'	3.3	0.1	0.6	1.1	1.7	2.2	2.8	3.2	11.7
-30'	3.5	0.1	0.6	1.2	1.8	2.3	2.9	3.4	12.3
-40'	3.7	0.1	0.6	1.2	1.8	2.4	3.1	3.6	12.8
-50'	3.8	0.1	0.6	1.3	1.9	2.6	3.2	3.7	13.4
4°-00'	4.0	0.1	0.7	1.3	2.0	2.7	3.3	3.9	14.0
-10'	4.2	0.1	0.7	1.4	2.1	2.8	3.5	4.1	14.7
-20'	4.3	0.1	0.7	1.4	2.2	2.9	3.6	4.2	15.1
-30'	4.5	0.1	0.8	1.5	2.2	3.0	3.8	4.4	15.8
-40'	4.7	0.1	0.8	1.6	2.3	3.1	3.9	4.6	16.4
-50'	4.8	0.1	0.8	1.6	2.4	3.2	4.0	4.7	16.8
5°-00'	5.0	0.1	0.8	1.7	2.5	3.3	4.2	4.9	17.5
-10'	5.2	0.1	0.9	1.7	2.6	3.4	4.3	5.1	18.1
-20'	5.3	0.1	0.9	1.8	2.7	3.6	4.4	5.2	18.7
-30'	5.5	0.2	0.9	1.8	2.8	3.7	4.6	5.3	19.3
-40'	5.7	0.2	0.9	1.9	2.8	3.8	4.7	5.5	19.8
-50'	5.8	0.2	1.0	1.9	2.9	3.9	4.9	5.6	20.4
6°-00'	6.0	0.2	1.0	2.0	3.0	4.0	5.0	5.8	21.0
-10'	6.2	0.2	1.0	2.1	3.1	4.1	5.1	6.0	21.6
-20'	6.3	0.2	1.1	2.1	3.2	4.2	5.3	6.1	22.2
-30'	6.5	0.2	1.1	2.2	3.2	4.3	5.4	6.3	22.7
-40'	6.7	0.2	1.1	2.2	3.3	4.4	5.6	6.5	23.3
-50'	6.8	0.2	1.1	2.3	3.4	4.6	5.7	6.6	23.9
7°-00'	7.0	0.2	1.2	2.3	3.5	4.7	5.8	6.8	24.5
-10'	7.2	0.2	1.2	2.4	3.6	4.8	6.0	7.0	25.2
-20'	7.3	0.2	1.2	2.4	3.7	4.9	6.1	7.1	25.6
-30'	7.5	0.2	1.2	2.5	3.8	5.0	6.2	7.3	26.2
-40'	7.7	0.2	1.3	2.6	3.8	5.1	6.4	7.5	26.9
-50'	7.8	0.2	1.3	2.6	3.9	5.2	6.5	7.6	27.3
8°-00'	8.0	0.2	1.3	2.7	4.0	5.3	6.7	7.8	28.0
-10'	8.2	0.2	1.4	2.7	4.1	5.4	6.8	8.0	28.6
-20'	8.3	0.2	1.4	2.8	4.2	5.6	6.9	8.1	29.2
-30'	8.5	0.2	1.4	2.8	4.2	5.7	7.1	8.3	29.7
-40'	8.7	0.2	1.4	2.9	4.3	5.8	7.2	8.5	30.3
-50'	8.8	0.2	1.5	2.9	4.4	5.9	7.4	8.6	30.9
9°-00'	9.0	0.2	1.5	3.0	4.5	6.0	7.5	8.8	31.5
-10'	9.2	0.3	1.5	3.1	4.6	6.1	7.6	8.9	32.1
-20'	9.3	0.3	1.6	3.1	4.7	6.2	7.8	9.0	32.7
-30'	9.5	0.3	1.6	3.2	4.8	6.3	7.9	9.2	33.3
-40'	9.7	0.3	1.6	3.2	4.8	6.4	8.1	9.4	33.8
-50'	9.8	0.3	1.6	3.3	4.9	6.6	8.2	9.5	34.4
10°-00'	10.0	0.3	1.7	3.3	5.0	6.7	8.3	9.7	35.0
-10'	10.2	0.3	1.7	3.4	5.1	6.8	8.5	9.9	35.7
-20'	10.3	0.3	1.7	3.4	5.2	6.9	8.6	10.0	36.1
-30'	10.5	0.3	1.8	3.5	5.2	7.0	8.8	10.2	36.8
-40'	10.7	0.3	1.8	3.6	5.3	7.1	8.9	10.4	37.4
-50'	10.8	0.3	1.8	3.6	5.4	7.2	9.0	10.5	37.8
11°-00'	11.0	0.3	1.8	3.7	5.5	7.3	9.2	10.7	38.5
-10'	11.2	0.3	1.9	3.7	5.6	7.4	9.3	10.9	39.1
-20'	11.3	0.3	1.9	3.8	5.7	7.6	9.4	11.0	39.7
-30'	11.5	0.3	1.9	3.8	5.7	7.7	9.6	11.2	40.2
-40'	11.7	0.3	1.9	3.9	5.8	7.8	9.7	11.4	40.8
-50'	11.8	0.3	2.0	3.9	5.9	7.9	9.9	11.5	41.4
12°-00'	12.0	0.3	2.0	4.0	6.0	8.0	10.0	11.7	42.0

MID-ORDINATES FOR SPIRAL 217' LONG (7 STATIONS)

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral: Zero (T.S.)	1	2	3	4	5	6	7 (S.C.)	Sum of Ordinates
1°-00'	1.0	0.0	0.1	0.3	0.4	0.6	0.7	0.9	1.0	4.0
-10'	1.2	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	4.7
-20'	1.3	0.0	0.2	0.4	0.6	0.8	1.0	1.1	1.3	5.4
-30'	1.5	0.0	0.2	0.4	0.6	0.9	1.1	1.3	1.5	6.0
-40'	1.7	0.0	0.2	0.5	0.7	1.0	1.2	1.4	1.7	6.7
-50'	1.8	0.0	0.3	0.5	0.8	1.0	1.3	1.6	1.8	7.3
2°-00'	2.0	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0	8.0
-10'	2.2	0.1	0.3	0.6	0.9	1.2	1.5	1.9	2.1	8.6
-20'	2.3	0.1	0.3	0.7	1.0	1.3	1.7	2.0	2.2	9.3
-30'	2.5	0.1	0.4	0.7	1.1	1.4	1.8	2.1	2.4	10.0
-40'	2.7	0.1	0.4	0.8	1.1	1.5	1.9	2.3	2.6	10.7
-50'	2.8	0.1	0.4	0.8	1.2	1.6	2.0	2.4	2.7	11.2
3°-00'	3.0	0.1	0.4	0.9	1.3	1.7	2.1	2.6	2.9	12.0
-10'	3.2	0.1	0.5	0.9	1.4	1.8	2.3	2.7	3.1	12.8
-20'	3.3	0.1	0.5	1.0	1.4	1.9	2.4	2.9	3.2	13.4
-30'	3.5	0.1	0.5	1.0	1.5	2.0	2.5	3.0	3.4	14.0
-40'	3.7	0.1	0.5	1.0	1.6	2.1	2.6	3.1	3.6	14.6
-50'	3.8	0.1	0.5	1.1	1.6	2.2	2.7	3.3	3.7	15.2
4°-00'	4.0	0.1	0.6	1.1	1.7	2.3	2.9	3.4	3.9	16.0
-10'	4.2	0.1	0.6	1.2	1.8	2.4	3.0	3.6	4.1	16.8
-20'	4.3	0.1	0.6	1.2	1.9	2.5	3.1	3.7	4.2	17.3
-30'	4.5	0.1	0.6	1.3	1.9	2.6	3.2	3.9	4.4	18.0
-40'	4.7	0.1	0.7	1.3	2.0	2.7	3.4	4.0	4.6	18.8
-50'	4.8	0.1	0.7	1.4	2.1	2.8	3.5	4.1	4.7	19.4
5°-00'	5.0	0.1	0.7	1.4	2.1	2.9	3.6	4.3	4.9	20.0
-10'	5.2	0.1	0.7	1.5	2.2	3.0	3.7	4.4	5.1	20.7
-20'	5.3	0.1	0.8	1.5	2.3	3.0	3.8	4.6	5.2	21.3
-30'	5.5	0.1	0.8	1.6	2.4	3.1	3.9	4.7	5.4	22.0
-40'	5.7	0.1	0.8	1.6	2.4	3.2	4.0	4.9	5.6	22.6
-50'	5.8	0.1	0.8	1.7	2.5	3.3	4.2	5.0	5.7	23.3
6°-00'	6.0	0.1	0.9	1.7	2.6	3.4	4.3	5.1	5.9	24.0
-10'	6.2	0.1	0.9	1.8	2.6	3.5	4.4	5.3	6.1	24.7
-20'	6.3	0.2	0.9	1.8	2.7	3.6	4.5	5.4	6.1	25.2
-30'	6.5	0.2	0.9	1.9	2.8	3.7	4.6	5.6	6.3	26.0
-40'	6.7	0.2	1.0	1.9	2.9	3.8	4.8	5.7	6.5	26.8
-50'	6.8	0.2	1.0	2.0	2.9	3.9	4.9	5.9	6.6	27.4
7°-00'	7.0	0.2	1.0	2.0	3.0	4.0	5.0	6.0	6.8	28.0
-10'	7.2	0.2	1.0	2.0	3.1	4.1	5.1	6.1	7.0	28.6
-20'	7.3	0.2	1.0	2.1	3.1	4.2	5.2	6.3	7.1	29.2
-30'	7.5	0.2	1.1	2.1	3.2	4.3	5.4	6.4	7.3	30.0
-40'	7.7	0.2	1.1	2.2	3.3	4.4	5.5	6.6	7.5	30.8
-50'	7.8	0.2	1.1	2.2	3.4	4.5	5.6	6.7	7.6	31.3
8°-00'	8.0	0.2	1.1	2.3	3.4	4.6	5.7	6.9	7.8	32.0
-10'	8.2	0.2	1.2	2.3	3.5	4.7	5.8	7.0	8.0	32.7
-20'	8.3	0.2	1.2	2.4	3.6	4.8	6.0	7.1	8.1	33.4
-30'	8.5	0.2	1.2	2.4	3.6	4.9	6.1	7.3	8.3	34.0
-40'	8.7	0.2	1.2	2.5	3.7	5.0	6.2	7.4	8.5	34.7
-50'	8.8	0.2	1.3	2.5	3.8	5.0	6.3	7.6	8.6	35.3
9°-00'	9.0	0.2	1.3	2.6	3.9	5.1	6.4	7.7	8.8	36.0
-10'	9.2	0.2	1.3	2.6	3.9	5.2	6.5	7.9	9.0	36.6
-20'	9.3	0.2	1.3	2.7	4.0	5.3	6.7	8.0	9.1	37.3
-30'	9.5	0.2	1.4	2.7	4.1	5.4	6.8	8.1	9.3	38.0
-40'	9.7	0.2	1.4	2.8	4.1	5.5	6.9	8.3	9.5	38.7
-50'	9.8	0.2	1.4	2.8	4.2	5.6	7.0	8.4	9.6	39.2
10°-00'	10.0	0.2	1.4	2.9	4.3	5.7	7.1	8.6	9.8	40.0
-10'	10.2	0.2	1.5	2.9	4.4	5.8	7.3	8.7	10.0	40.8
-20'	10.3	0.2	1.5	3.0	4.4	5.9	7.4	8.9	10.1	41.4
-30'	10.5	0.2	1.5	3.0	4.5	6.0	7.5	9.0	10.3	42.0
-40'	10.7	0.3	1.5	3.0	4.6	6.1	7.6	9.1	10.4	42.6
-50'	10.8	0.3	1.5	3.1	4.6	6.2	7.7	9.3	10.5	43.2
11°-00'	11.0	0.3	1.6	3.1	4.7	6.3	7.9	9.4	10.7	44.0
-10'	11.2	0.3	1.6	3.2	4.8	6.4	8.0	9.6	10.9	44.8
-20'	11.3	0.3	1.6	3.2	4.9	6.5	8.1	9.7	11.0	45.3
-30'	11.5	0.3	1.6	3.3	4.9	6.6	8.2	9.9	11.2	46.0
-40'	11.7	0.3	1.7	3.3	5.0	6.7	8.3	10.0	11.4	46.7
-50'	11.8	0.3	1.7	3.4	5.1	6.8	8.5	10.1	11.5	47.4
12°-00'	12.0	0.3	1.7	3.4	5.1	6.9	8.6	10.3	11.7	48.0

MID-ORDINATES FOR SPIRAL 248' LONG (8 STATIONS)

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral: Zero (T.S.)	1	2	3	4	5	6	7	8 (S.C.)	Sum of Ordinates
1°-00'	1.0	0.0	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	4.4
-10'	1.2	0.0	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	5.2
-20'	1.3	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	6.0
-30'	1.5	0.0	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.5	6.7
-40'	1.7	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.5	1.7	7.4
-50'	1.8	0.0	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	8.2
2°-00'	2.0	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0	8.8
-10'	2.2	0.0	0.3	0.5	0.8	1.1	1.4	1.6	1.9	2.2	9.8
-20'	2.3	0.0	0.3	0.6	0.9	1.2	1.5	1.7	2.0	2.3	10.5
-30'	2.5	0.1	0.3	0.6	0.8	1.2	1.6	1.9	2.2	2.4	11.2
-40'	2.7	0.1	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.6	12.0
-50'	2.8	0.1	0.4	0.7	1.1	1.4	1.8	2.1	2.5	2.7	12.8
3°-00'	3.0	0.1	0.4	0.7	1.1	1.5	1.9	2.2	2.6	2.9	13.4
-10'	3.2	0.1	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.1	14.4
-20'	3.3	0.1	0.4	0.8	1.2	1.7	2.1	2.5	2.9	3.2	14.9
-30'	3.5	0.1	0.4	0.9	1.3	1.7	2.2	2.6	3.1	3.4	15.7
-40'	3.7	0.1	0.5	0.9	1.4	1.8	2.3	2.7	3.2	3.6	16.5
-50'	3.8	0.1	0.5	1.0	1.4	1.9	2.4	2.9	3.4	3.7	17.3
4°-00'	4.0	0.1	0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.9	18.0
-10'	4.2	0.1	0.5	1.0	1.6	2.1	2.6	3.1	3.6	4.1	18.7
-20'	4.3	0.1	0.5	1.1	1.6	2.2	2.7	3.2	3.8	4.2	19.4
-30'	4.5	0.1	0.6	1.1	1.7	2.2	2.8	3.4	3.9	4.4	20.2
-40'	4.7	0.1	0.6	1.2	1.7	2.3	2.9	3.5	4.1	4.6	21.0
-50'	4.8	0.1	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.7	21.6
5°-00'	5.0	0.1	0.6	1.2	1.9	2.5	3.1	3.7	4.4	4.9	22.4
-10'	5.2	0.1	0.6	1.3	1.9	2.6	3.2	3.9	4.5	5.1	23.2
-20'	5.3	0.1	0.7	1.3	2.0	2.7	3.3	4.0	4.7	5.2	24.0
-30'	5.5	0.1	0.7	1.4	2.1	2.7	3.4	4.1	4.8	5.4	24.7
-40'	5.7	0.1	0.7	1.4	2.1	2.8	3.5	4.2	5.0	5.6	25.4
-50'	5.8	0.1	0.7	1.5	2.2	2.9	3.6	4.4	5.1	5.7	26.2
6°-00'	6.0	0.1	0.7	1.5	2.2	3.0	3.7	4.5	5.2	5.9	26.8
-10'	6.2	0.1	0.8	1.5	2.3	3.1	3.9	4.6	5.4	6.1	27.8
-20'	6.3	0.1	0.8	1.6	2.4	3.2	4.0	4.7	5.5	6.2	28.5
-30'	6.5	0.1	0.8	1.6	2.4	3.2	4.1	4.9	5.7	6.4	29.

MID-ORDINATES FOR SPIRAL 279' LONG (9 STATIONS)

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral Zero (T.S.)	1	2	3	4	5	6	7	8	9 (S.C.)	Sum Of Ordinates
1°-00'	1.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0	5.0
-10'	1.2	0.0	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	5.8
-20'	1.3	0.0	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3	6.5
-30'	1.5	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	7.5
-40'	1.7	0.0	0.2	0.4	0.6	0.7	0.9	1.1	1.3	1.5	1.7	8.4
-50'	1.8	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	9.0
2°-00'	2.0	0.0	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.0	10.0
-10'	2.2	0.0	0.2	0.5	0.7	1.0	1.2	1.4	1.7	1.9	2.2	10.8
-20'	2.3	0.0	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.3	11.7
-30'	2.5	0.0	0.3	0.6	0.8	1.1	1.4	1.7	1.9	2.2	2.5	12.5
-40'	2.7	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	13.5
-50'	2.8	0.1	0.3	016	0.9	1.3	1.6	1.9	2.2	2.5	2.7	14.1
3°-00'	3.0	0.1	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.7	2.9	15.0
-10'	3.2	0.1	0.4	0.7	1.1	1.4	1.8	2.1	2.5	2.8	3.1	16.0
-20'	3.3	0.1	0.4	0.7	1.1	1.5	1.9	2.2	2.6	3.0	3.2	16.7
-30'	3.5	0.1	0.4	0.8	11.2	1.6	1.9	2.3	2.7	3.1	3.4	17.5
-40'	3.7	0.1	0.4	0.8	1.2	1.6	2.0	2.4	2.9	3.3	3.6	18.3
-50'	3.8	0.1	0.4	0.9	1.3	1.7	2.1	2.6	3.0	3.4	3.7	19.3
4°-00'	4.0	0.1	0.4	0.9	1.3	1.8	2.2	2.7	3.1	3.6	3.9	20.0
-10'	4.2	0.1	0.5	0.9	1.4	1.9	2.3	2.8	3.2	3.7	4.1	20.9
-20'	4.3	0.1	0.5	1.0	1.4	1.9	2.4	2.9	3.4	3.9	4.2	21.7
-30'	4.5	0.1	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.4	22.5
-40'	4.7	0.1	0.5	1.0	1.6	2.1	2.6	3.1	3.6	4.1	4.6	23.3
-50'	4.8	0.1	0.5	1.1	1.6	2.1	2.7	3.2	3.8	4.3	4.7	24.1
5°-00'	5.0	0.1	0.6	1.1	1.7	2.2	2.8	3.3	3.9	4.4	4.9	25.0

MID-ORDINATES FOR SPIRAL 310' LONG (10 STATIONS

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral Zero (T.S.)	1	2	3	4	5	6	7	8	9	10 (S.C.)	Sum of Ordinates
1°-00'	1.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	5.5
-10'	1.2	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	6.3
-20'	1.3	0.0	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2	1.3	7.3
-30'	1.5	0.0	0.1	0.3	0.4	0.6	0.7	0.9	1.9	1.2	1.3	1.5	8.0
-40'	1.7	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7	9.2
-50'	1.8	0.0	0.2	0.4	0.5	0.7	0.9	1.1	1.3	1.5	1.6	1.8	10.0
2°-00'	2.0	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	11.0
-10'	2.2	0.0	0.2	0.4	0.6	0.9	1.1	1.3	1.5	1.7	1.9	2.2	11.8
-20'	2.3	0.0	0.2	0.5	0.7	0.9	1.2	1.4	1.6	1.9	2.1	2.3	12.8
-30'	2.5	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2	2.5	13.5
-40'	2.7	0.0	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1	2.4	2.7	14.7
-50'	2.8	0.0	0.3	0.6	0.8	1.1	1.4	1.7	2.0	2.3	2.5	2.8	15.5
3°-00'	3.0	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	16.5
-10'	3.2	0.1	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.8	3.1	17.3
-20'	3.3	0.1	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.2	18.3
-30'	3.5	0.1	0.3	0.7	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.4	19.0
-40'	3.7	0.1	0.4	0.7	1.1	1.5	1.8	2.2	2.6	2.9	3.3	3.6	20.2
-50'	3.8	0.1	0.4	0.8	1.1	1.5	1.9	2.3	2.7	3.1	3.4	3.7	21.0
4°-00'	4.0	0.1	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	3.9	22.0

MID-ORDINATES FOR SPIRAL 341' LONG (11 STATIONS)

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral Zero (T.S.)	1	2	3	4	5	6	7	8	9	10	11	Sum of Ordinates
1°-00'	1.0	0.0	0.1	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	6.0
-10'	1.2	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.2	6.9
-20'	1.3	0.0	0.1	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	7.9
-30'	1.5	0.0	0.1	0.3	0.4	0.5	0.7	0.8	1.0	1.1	1.2	1.4	1.5	9.0
-40'	1.7	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	10.2
-50'	1.8	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	11.0
2°-00'	2.0	0.0	0.2	0.4	0.5	0.7	0.9	1.1	1.3	1.5	1.6	1.8	2.0	12.0
-10'	2.2	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	13.2
-20'	2.3	0.0	0.2	0.4	0.6	0.8	1.1	1.3	1.5	1.7	1.9	2.1	2.3	13.9
-30'	2.5	0.0	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	2.0	2.3	2.5	15.0
-40'	2.7	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7	1.9	2.2	2.4	2.7	16.0
-50'	2.8	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6	2.8	17.0
3°-00'	3.0	0.0	0.3	0.5	0.8	1.1	1.4	1.6	1.9	2.2	2.5	2.7	3.0	18.0

MID-ORDINATES FOR SPIRAL 372' LONG (12 STATIONS)

rer f ular ve	Ordinate of Circular Curve	Stations on Spiral Zero (T.S.)	1	2	3	4	5	6	7	8	9	10	11	12 (S.C.)	Sum of Ordinates
·00'	1.0	0.0	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0	6.4
·10'	1.2	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	7.8
·20'	1.3	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	8.6
·30'	1.5	0.0	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2	1.4	1.5	9.6
·40'	1.7	0.0	0.1	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.7	10.8
·50'	1.8	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	12.0
·00'	2.0	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0	13.0
·10'	2.2	0.0	0.2	0.4	0.5	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.2	14.1
·20'	2.3	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3	15.2
·30'	2.5	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.5	1.7	1.9	2.1	2.3	2.5	16.2
·40'	2.7	0.0	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2	2.4	2.7	17.3
·50'	2.8	0.0	0.2	0.5	0.7	0.9	1.2	1.4	1.7	1.9	2.1	2.4	2.6	2.8	18.4
·00'	3.0	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7	3.0	19.2

MID-ORDINATES FOR SPIRAL 403' LONG (13 STATIONS)

Degree of Circular Curve	Ordinate of Circular Curve	Stations on Spiral Zero (T.S.)	1	2	3	4	5	6	7	8	9	10	11	12	13 (S.C.)	Sum of Ordinates
1°-00'	1.0	0.0	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	7.0
-10'	1.2	0.0	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	8.2
-20'	1.3	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	9.1
-30'	1.5	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	10.5
-40'	1.7	0.0	0.1	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.7	11.7
-50'	1.8	0.0	0.1	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.7	1.8	12.8
2°-00'	2.0	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0	14.0
-10'	2.2	0.0	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2	15.2
-20'	2.3	0.0	0.2	0.4	0.5	0.7	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.3	16.4
-30'	2.5	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.5	17.5
-40'	2.7	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.1	2.3	2.5	2.7	18.6
-50'	2.8	0.0	0.2	0.4	0.6	0.9	1.1	1.3	1.5	1.7	2.0	2.2	2.4	2.6	2.8	19.7
3°-00'	3.0	0.0	0.2	0.5	0.7	0.9	1.2	1.4	1.6	1.8	2.1	2.3	2.5	2.8	3.0	21.0

In order to check these formulae against the AREA spiral, the rectangular co-ordinates for a 217′ spiral for a 5°–00′ curve were calculated for each 31′ station and the mid-ordinates computed therefrom. The following table and diagram show a comparison of the results.

Station	*Mid-Ordinate by Rectangular Co-Ordinates*	*Mid-Ordinates by Formulae Used in Tables*
0+00 = 0 = *T.S.*	0.00998′ = 0.12″	0.12″
0+31 = 1	0.05989′ = 0.72″	0.71″
0+62 = 2	0.11983′ = 1.44″	1.43″
0+93 = 3	0.17962′ = 2.16″	2.14″
1+24 = 4	0.23938′ = 2.87″	2.86″
1+55 = 5	0.29880′ = 3.59″	3.57″
1+86 = 6	0.35760′ = 4.29″	4.29″
2+17 = 7 = *S.C.*	0.4062′ = 4.87″	4.88″

The greatest variation is 0.02 inch.

Appendix D

(3) PLANS AND SPECIFICATIONS FOR TRACK TOOLS

G. M. Strachan, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bevan, H. R. Clarke, L. W. DesLauriers, J. J. Desmond, F. S. Hales, F. W. Hillman, E. T. Howson, T. T. Irving, J. B. Myers, J. V. Neubert, C. J. Rist, W. L. Roller, G. L. G. Smith, J. R. Watt, J. G. Wishart.

In the Proceedings, Vol. 31, 1930, the Committee submitted the following as information:

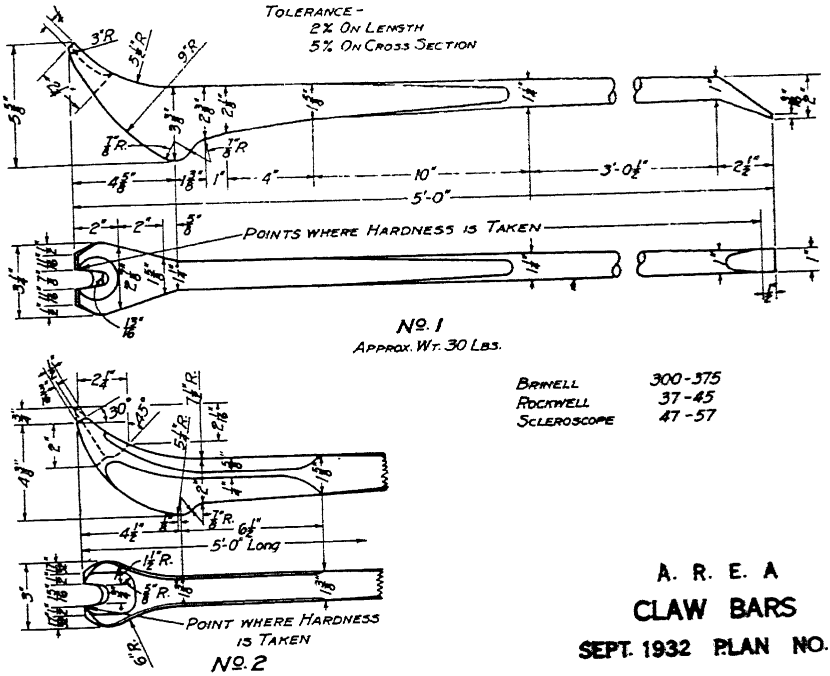
(1) General specification covering chemistry and physical test for track tools.
(2) Specifications covering hickory handles for track tools.
(3) Plans and specifications for track shovels.
(4) Plans and specifications for ballast forks.

Some further work has been done during the year on these plans and specifications, but due to the small number of track tools purchased this year and placed in service, all controversial points have not been adjusted. The Committee recommends that these plans and specifications be considered as information for another year.

Further investigation of Plan No. 11—Claw Bar, dated September, 1929, adopted by the Association in 1930, indicates the need for an alternate design. Plan No. 11 has been redrafted to include an alternate Claw Bar. This redrafted plan, bearing date of September, 1932, is submitted with recommendation that it replace the present Plan No. 11 appearing in the Manual.

Conclusions

The Committee recommends that the present Plan No. 11—Claw Bar, dated September, 1929, be withdrawn from the Manual and that Plan No. 11, dated September, 1932, showing approved Claw Bar No. 1 and alternate Claw Bar No. 2 be substituted therefor.



A. R. E. A

CLAW BARS

SEPT. 1932 PLAN NO. 11

Appendix E

(4) PLANS FOR SWITCHES, FROGS, CROSSINGS, SLIP SWITCHES, ETC.

O. F. Harting, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, C. A. Alden, W. G. Arn, L. H. Bond, R. W. E. Bowler, H. W. Brown, W. G. Brown, E. W. Caruthers, J. W. DeMoyer, L. W. DesLauriers, J. A. Ellis, F. W. Gardiner, W. G. Hulbert, T. T. Irving, J. de N. Macomb, F. H. Masters, J. C. Mock, A. J. Neafie, G. A. Peabody, O. C. Rehfuss, C. J. Rist, E. M. T. Ryder, G. L. Sitton, G. J. Slibeck, Theo. Speiden, Jr., H. C. Stiff, G. M. Strachan, C. R. Strattman, J. B. Strong, E. D. Swift, H. N. West, J. G. Wishart.

The plan presented in this Appendix, and the Revision of the Manual in Appendix A coming under this subject, have been prepared in conference with the Standardization Committee of the Manganese Track Society.

The Committee presents, for adoption as recommended practice, Plan No. 600-A, showing the application of wing wheel risers to manganese steel frogs, railbound, solid and self-guarded. This feature for manganese steel frogs is now in general use and the plan was prepared to assure uniform practice, when wing wheel risers are wanted.

Some of the railways have experienced broken switch points, made of rolled manganese steel rails, due to the progression of incipient cracks at the bolt holes. Tests made by the Lorain Steel Company and the Bethlehem Steel Company indicate that the holes should be drilled and not punched and that the burrs should be removed by grinding.

The Committee reports progress on a number of other assignments.

Conclusions

The Committee recommends that the following plan, submitted herewith, be adopted as recommended practice and printed in the Manual: Plan No. 600-A, dated September, 1932—A.R.E.A. Application of Wing Wheel Risers to Manganese Steel Frogs Railbound, Solid and Solid Self-Guarded.

The Committee also offers as information the following recommendation:

That the bolt holes in switch points made of rolled manganese steel rails be drilled and not punched and that the burrs be removed by grinding.

The Committee recommends that this subject be continued.

Appendix F

(5) TRACK CONSTRUCTION IN PAVED STREETS

E. W. Caruthers, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, C. A. Alden, H. W. Brown, W. G. Brown, J. E. Deckert, J. W. DeMoyer, O. F. Harting, W. G. Hulbert, J. de N. Macomb, J. C. Mock, A. J. Neafie, G. A. Peabody, O. C. Rehfuss, E. M. T. Ryder, G. J. Slibeck, Theo. Speiden, Jr., H. C. Stiff, C. R. Strattman, J. B. Strong, T. P. Warren, H. N. West.

Plans 987, "Straight Double Tongue Switches for Engine Wheel Base Not Over 14 ft. 6 in. for Use in Paved Streets", and 988, "Straight Double Tongue Switches for Engine Wheel Base Over 14 ft. 6 in., but not exceeding 19 ft. 0 in. for Use in Paved Streets", were offered at the Convention in 1932 for information. No adverse comments have been received and your Committee now wishes to offer the plans for adoption as "Recommended Practice".

Note.—For plans above enumerated see Bulletin 352, December, 1932.

These plans have been prepared in conference with the Manganese Track Society, and embody the general details of design, and are interchangeable with switches of this type now in use by some railroads.

Conclusions

The Committee recommends that Plans 987, "Straight Double Tongue Switches for Engine Wheel Base not over 14 ft. 6 in. for Use in Paved Streets", dated November, 1931, and 988, "Straight Double Tongue Switches for Engine Wheel Base over 14 ft. 6 in., but not exceeding 19 ft. 0 in. for Use in Paved Streets", dated November, 1931, be adopted as "Recommended Practice" and printed in the Manual.

Appendix G

(6) CORROSION OF RAIL AND FASTENINGS IN TUNNELS

C. J. Geyer, Chairman, Sub-Committee; C. R. Harding, W. H. Bettis, L. H. Bond, R. W. E. Bowler, C. W. Breed, J. J. Desmond, F. W. Gardiner, W. J. Harris, F. W. Hillman, E. T. Howson, H. D. Knecht, J. de N. Macomb, F. H. Masters, C. M. McVay, O. C. Rehfuss, I. H. Schram, Theo. Speiden, Jr.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year.

Appendix H

(7) GAGE OF TRACK AND ELEVATION OF CURVES WITH REFERENCE TO THE USE OF ROLLER BEARINGS ON RAILWAY EQUIPMENT, COLLABORATING WITH THE MECHANICAL DIVISION, A.R.A.

C. W. Breed, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bettis, L. H. Bond, F. S. Hales, J. E. Hogan, E. T. Howson, C. M. McVay, C. R. Strattman, T. P. Warren.

The elevation of curves must be governed primarily by the speed of trains passing over them. If the use of roller bearings because of mechanical construction were a controlling factor of the speed of trains in which they might be used to that extent, might they be an element in selecting the proper elevations of curves over which the train passed?

In order to obtain accurate information relative to the possible limits in the use of roller bearings on curves at any desired speed of operation, letters of inquiry were addressed to the large manufacturers of roller bearings which elicited the following replies:

Fafnir Bearings Incorporated, New Britain, Connecticut—"We have been over this subject carefully with our engineering department, and beg to advise that the problem, as far as it relates to the use of our roller bearing, the same standards would apply as on the sleeve bearings."

Hyatt Bearings Division, General Motors Corporation, Newark, New Jersey—"From the standpoint of Hyatt roller bearing applications to rolling stock, we do not see that there are any problems involved with the Hyatt application which are not present with the brass bearing application."

Shafer Bearing Corporation, 6501–99 W. Grand Ave., Chicago—"With Shafer roller bearing used in railroad equipment, fitted in American Steel Foundry units, the axle shaft is stationary and is corrected in regular journal boxes, with no change in lateral clearance. For this reason their action on curves will be identically the same as the standard plain bearings."

SKF INDUSTRIES, INC., 40 East 34th Street, New York—"We have been using the S K F Spherical Roller Bearing for journal applications for more than ten years and have had extensive experience with practically all types of steam railway equipment except freight cars. We have done some work with freight cars but very little in comparison to that represented by the use of these bearings on passenger trains equipment and locomotive.

"The questions raised in your letter are not ones which we have had occasion to study or investigate thoroughly. Up to the present time we have seen nothing to indicate that any special requirements for gage of track or elevation of the outer rail on curves are necessary when the spherical journal bearing is used."

THE TIMKEN ROLLER BEARING COMPANY, Canton, Ohio—"On the subject of track gage and elevation of curves, we are of the opinion that no changes should be made in the tables because of roller bearings. Any new conditions which may arise from the use of roller bearings should properly be confined to the rolling stock so equipped. The formula for elevation of the outer rail on a curve is a function of speed and degree of curvature only. The condition of rolling stock does not enter in except as it may affect speed. We have noted a marked tendency to introduce roller bearings on high speed equipment. As the modern trend is toward higher speeds, some changes in track may be made, but no changes in the tables are involved.

"Regarding lateral play at journal boxes, we have found it possible to obtain any desired amount of movement between box and frame as designed for Timken bearings. Wheel gages can also be varied. These possibilities are fortunate, as the table for gages and flangeways already contains a large number of factors and should not be made more complicated."

Conclusions

There is no different problem in the selection of the proper elevation for curves over which it is desired to operate railway equipment using roller bearings than is present if equipment is supplied with ordinary bearings.

It is recommended that this report be considered as information.

Appendix I

(8) EFFECT OF EXISTING MATERIALS IN TRACK ON THE DESIGN OF TIE PLATES AND PUNCHING THEREOF, TOGETHER WITH THE INTER-RELATION OF SLOTTING OF JOINT BARS AND SIZE OF TRACK SPIKES

J. de N. Macomb, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. G. Arn, W. H. Bevan, R. W. E. Bowler, W. G. Brown, E. W. Caruthers, H. R. Clarke, J. W. DeMoyer, L. W. DesLauriers, J. A. Ellis, W. J. Harris, O. F. Harting, F. W. Hillman, F. J. Jerome, H. D. Knecht, F. H. Masters, J. B. Myers, A. J. Neafie, J. V. Neubert, C. J. Rist, W. L. Roller, I. H. Schram, G. L. G. Smith, Theo. Speiden, Jr., E. D. Swift, J. R. Watt.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year.

Appendix J

(9) PRACTICABILITY OF USING REFLEX UNITS FOR SWITCH LAMPS AND TARGETS

J. B. Myers, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, C. A. Alden, F. J. Jerome, H. D. Knecht, J. C. Mock, A. J. Neafie.

This subject is one of considerable interest at this time, due to the economy effected by the elimination of oil burning switch lamps and its attendant labor costs for cleaning, lighting and care.

A questionnaire was sent out to a selected list of railroads who were reported to have used or were experimenting with some type of Reflex lens, and the following summary of answers is submitted as information.

Four types of Reflex Units were considered and to simplify answering, the different types were numbered:

No. 1—Button type, several of which are set in a panel of proper size to replace the individual lens in switch lamp.

No. 2—Button type, same as No. 1, but panels built into a complete lamp, replacing the present switch lamp.

No. 3—Cataphote or Cluster type, a lens having the reflecting buttons molded as part of the lens, which is of such size as to replace the lens in the present switch lamp.

No. 4—A reflector switch lamp, each reflector lens composed of reflecting mirrors enclosing a dry gas, such as the A. G. A. reflector switch lamp.

Number of railroads to whom questionnaire was sent	54
Number of railroads replying	42
Number of railroads not replying	12

Of the 42 railroads that replied:

Sixteen have made no tests and have none in service.

Three have made limited tests, with unsatisfactory results, and now have none in service.

Twenty have a limited number either in test or ready to install.

Three railroads have an appreciable number in service and appear definitely committed to their use.

Number Used by Railroads Reporting

	Auto. Signal Territory	*Non-Auto. Signal Territory*	*Side Tracks*	*Total*
Type No. 1	10	13	3	26
Type No. 2	4	563	0	567
Type No. 3	10	7	0	17
Type No. 4	64	44	2	110
Total	88	627	5	720

Angularity

Of the 42 railroads reporting, only 12 replied to this question.

		Replies
Type No. 1	3	3 report 30°
Type No. 2	4	3 report 30°; 1 reports 65°
Type No. 3	2	1 reports 30°; 1 reports 80°
Type No. 4	9	5 report 30°; 3 report 60° and 1 reports 80°

Distance Visible

Of the 42 railroads, only 12 replied to this question, and they agreed that the colors red and green were visible for about the same distance:

		Replies
Type No. 1	3	2 report 2000′; 1 reports 2500′
Type No. 2	5	1 reports 1000′; 1 reports 2000′; 1 reports 2200′; 1 reports 2500′; and 1 reports 3000′
Type No. 3	2	1 reports 1600′; 1 reports 4000′
Type No. 4	9	1 reports 1200′; 3 report 2500′; 1 reports 3000′; 1 reports 3300′; 1 reports 4000′; and 1 reports 1600′

Distance Types Remain True to Colors

Of the 42 railroads, only 12 made definite reply to this question. With two exceptions they agreed that the colors red and green held true for the full distance visible. One road indicated that the colors held true for about three-fourths of the distance visible, and one road stated that the colors became indistinct as the distance increased.

Angularity and Visibility of Different Types and Colors Compared with Oil and Electric Lamps

Sixteen of the reporting railroads answered this question; five railroads say that the Reflex units are better than oil lamps; four say they compare favorably with oil lamps; six say they are inferior to oil or electric lamps; one feels they are not satisfactory on curves, and one states they are better on curves than oil lamps.

Annual Cost of Lamps (Eighteen railroads replied)

	Replies	*Range*
Oil lighted	20	$6.23 to $21.00
Electric lighted	7	2.00 to 15.00
Reflex Units	3	.50 to 3.00

Is Banner Retained for Day Indications Where Reflex Units are Used?

Fifteen railroads replied to this question: 14 yes and 1 no.

Has the Use of Reflex Units Passed the Experimental Stage?

Twenty of the reporting railroads answered this question: 17 no and 3 yes.

Do You Contemplate the Use of Some Type of Reflex Unit for Oil or Electric Lamps?

Twenty-three of the reporting roads replied to this question: 11 replied no; 9 have the matter under consideration and are waiting on the results of tests, and 3 roads are definitely committed to their use.

Use of Reflex Units in Other Units than Switch Lamps

Twenty-two railroads replied to this question: 16 railroads replied no; 1 road uses them for permanent proceed signal; 1 road used them on the arms of crossing gates; 1 road uses them as "A" and "T" markers on automatic block signals to denote "ABSOLUTE" and "TONNAGE" signals; 1 road uses them on steel masts as a fixed distant signal at automatic interlocking plants in non-automatic signal territory; 1 railroad uses them as markers for semaphore signals and water pans, and 1 railroad as speed limit signs.

Do Laws in any of the States in which You Operate Prohibit the Use of Reflex Units or Definitely Prescribe Oil or Electric Lamps?

Twenty-four railroads replied to this question: 10 answered no, 8 answered yes, and 1 road operating in the State of Maine points out that the law on this point is a matter of interpretation. The States of Indiana, Michigan, Maine, Kansas, Nebraska, Missouri, Colorado, Louisiana and South Dakota are mentioned as having laws covering this feature. Roads operating in Canada must obtain consent to use Reflex Units from the Board of Railway Commissioners of Canada.

The above Summary includes replies from two French railroads who stated they had used experimentally the Type No. 3, Cataphote Cluster lens and expected to extend their use.

No definite conclusions can be reached now as to the efficiency of any type of Reflex unit as a substitute for oil or electric switch lamps. The general opinion appears to question the value of reflecting devices in winter months and during heavy fog. It is a fact, however, that the three railroads who have a large number of these units in service report satisfactory aspects during the entire year and these roads are so located that they at times do have adverse atmospheric conditions.

Conclusion

It is recommended that this report be received as information.

Appendix K

(10) SELECTIVE WELDING UP AT JOINTS, INSTEAD OF WELDING OUT OF FACE

W. G. Arn, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bettis, H. W. Brown, W. G. Brown, H. R. Clarke, L. W. DesLauriers, J. A. Ellis, F. W. Hillman, F. J. Jerome, H. D. Knecht, C. J. Rist, W. L. Roller, G. L. Sitton, G. M. Strachan, J. G. Wishart.

Oxy-acetylene Process

Twenty-nine railroad systems which have been building up rail ends in track for a number of years, or on an extensive scale, have replied to the questionnaire on this subject. A general summary of the replies to the questionnaire is given below:

Only four railroads report using the out-of-face method exclusively. The Atlantic Coast Line began in 1919, other railroads in subsequent years.

There are seven railroads which report using the Selective method exclusively. The Central of Georgia began in January 1917, and the Northern Pacific the same year; other railroads in subsequent years.

There are eighteen railroads which report that both methods are in use.

The method of determining when rail ends should be built up varies widely, a summary being as follows:

3	companies	when the wear exceeds	.03	of an inch
3	"	" " " "	1/32	" " "
3	"	" " " "	.04	" " "
5	"	" " " "	3/64	" " "
1	company	" " " "	.06	" " "
1	"	" " " "	1/16	" " "
1	"	" " " "	3/32	" " "
1	"	" " " "	.03	" " " and is less than 3/16 of an inch

11 companies leave the matter to the judgment of welding foreman, supervisor, roadmaster, division engineer or higher maintenance officer

The replies to Question No. 4 were not very enlightening. This question is as follows:

"If you use both 'out-of-face' and 'selective' building up of rail ends, what determines which method to be used in each location?"

Many of the replies to this question were the same as to Question No. 3, the other answers are summarized below:

- One builds up out of face when 40% have reached the allowable limit of wear.
- Two roads build up out of face when more than 50% of the rail ends have reached the allowable limit of wear.
- One company uses the out of face method on the low side of curves.
- One company uses the out-of-face method when practically all rail ends are worn to the established limit of wear.

The Selective method is used by various companies as follows:

- One company principally in yards and on the low side of curves.
- One company in yards and terminals only.
- One company only on curves and in special cases, such as washout or slide territory.
- Two companies only to a limited extent for worst joints until territory is ready for out-of-face method.
- One company only on comparatively new rail when there is considerable chipping, and also to harden ends of soft rail.
- Two other companies use it only in special cases.

Only a few of the roads report changing process or method or discontinuing the building up of rail ends. These cases are as follows:

- One company used for a while the Selective method only, and then discontinued it in favor of out-of-face.
- Two companies which have used both methods discontinued the Selective method after a limited use.
- One company, doing out-of-face work by oxyacetylene, has changed to out-of-face by electric welding, stating that it finds the cost lower and the work better.
- One company using both methods by oxyacetylene welding has changed to the spot method by electric welding.
- Two companies discontinued both methods temporarily—one on account of being well caught up with the work; and the other, to reduce expenses temporarily.

The expense of building up rail ends varies widely on the different roads. In cases where both methods were used and the expense of each method was not kept separate, the cost per joint was as follows:

1	Railroad	@	$0.75
1	"	@	0.91
1	"	@	0.90 to $1.00
1	"	@	1.14
1	"	@	1.21
1	"	@	1.31
1	"	@	1.35
1	"	@	1.62
1	"	@	1.65 to $2.00
1	"	@	1.25 to $3.00

For the Selective method only the following costs were given per joint:

1	Railroad had costs varying from		$0.60 to $1.00
1	"	@	0.85
1	"	@	0.94
1	"	@	0.97
1	"	@	1.11
2	"	@	1.33
1	"	@	0.94 to $1.79 (Average $1.37)
1	"	@	1.40 to $1.60
1	"	@	1.76
1	"	@	1.77
1	"	@	0.15 per lin. inch

By the Out-of-face method, costs per joint were as follows:

1	Railroad	@	$0.51 in 1931; $0.58 in 1930
1	"	@	0.47 to $1.20 (Average $0.77)
1	"	@	0.77
1	"	@	0.93
1	"	@	1.05 in 1932; $1.15 in 1931; (includes painting with black oil)
1	"	@	0.85 to $1.25 ($0.13 per lin. inch)
1	"	@	1.19
1	"	@	0.89 to $1.28
1	"	@	0.96 to $1.64 (Average $1.50)
1	"	@	1.65 (includes retamping)

One company reports that in addition to building up the rail ends they also build up the top of the angle bar where it has been worn down, this being done just before rail ends are built up. (C&NW).

One company reports that where rail ends are worn less than 1/32" at a joint, the end with the lesser wear is ground down to match the lower end. (Pennsylvania).

One company reports increasing the proportion of out-of-face work. (CMStP&P).

Electric Process

Fifteen railroad systems which have been building up rail ends in track on a rather extensive scale by the electric process, have replied to the questionnaire. A general summary of the replies is given below:

Nine railroads use the out-of-face method exclusively.

The C&NW began the out-of-face method in 1925, other roads in subsequent years.

Five railroads use the Selective method only.

The Southern Pacific began the Selective method in 1926, other roads subsequently.

Only one railroad reports using the electric process for both methods.

The method of determining when rail ends should be built up varies widely, a summary being as follows:

1	company	when the wear exceeds	.03 of an inch
2	companies	" " " "	1/32 " " "
3	"	" " " "	.04 " " "
3	"	" " " "	3/64 " " "
1	company	" " " "	.06 " " "
1	"	" " " "	1/16 " " "
1	"	" " " "	.03 " " " and is less than 3/16 of an inch
3	other companies leave the matter to the judgment of some maintenance officer		

One company builds up rail ends by the out-of-face method when 40 per cent or more of the joints have reached the allowable limit of wear; and

One when 50 per cent have reached the allowable limit of wear.

One company reports discontinuing the Selective Process temporarily, and

One the out-of-face process temporarily.

One company which used the Out-of-face Process only has discontinued this, due to excessive number of breaks on the welded ends.

One company reports discontinuing the Out-of-face method for one year account reduction in expenses.

One company is testing the electric process out-of-face.

One company which experimented with the electric process found it no better and more expensive.

The expense of building up rail ends varies widely, as is shown by the prices given below:

One company, using both methods, does the work at an average cost per joint of $1.25 (18¢ per lin. inch).

For the Selective Process, costs per joint were as follows:

1	company	@	$0.70
1	"	@	1.50 to $2.25
1	"	@	1.60
1	"	@	1.81
1	"	@	2.10

For the Out-of-face method costs per joint were as follows:

1	company	@	$1.50 to $1.75
1	"	@	1.70
1	"	@	1.70 to $1.80
1	"	@	1.75
1	"	@	1.87
1	"	@	1.95
1	"	@	1.96
1	"	@	2.00 to $2.25
1	"	@	0.11 per lin. inch

Recommendation

Unless companies already have some other satisfactory rule, and pending further investigation, the rule suggested is:

"That rail ends be built up by the Selective method before enough have worn down to the allowable limit of wear to justify out-of-face work; but where rail has run until 50 per cent of the joints have reached the limit of wear the work to be done by the Out-of-face method".

Conclusions

That this report be accepted as information, and the subject be continued as to:

Conditions governing choice of method.

Extent, if any, of increased rail breakage due to building up ends.

Use of new, reformed, or built up angle bars.

Wear on under side of head of rail.

Grinding instead of flattening after building up by oxyacetylene process.

That the question of heat treating rail ends to reduce wear be investigated and recommendations made.

Appendix L

(11) DESIRABLE TIGHTNESS OF TRACK JOINTS AND EFFECT UPON THE LIFE OF RAILS AND JOINTS OF OVERTIGHT JOINTS; OF LOOSE JOINTS

W. J. Harris, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bevan, H. R. Clarke, J. J. Desmond, J. E. Hogan, C. M. McVay, I. H. Schram, G. L. G. Smith, T. P. Warren.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year.

Appendix M

(12) RECLAMATION OF SERVICEABLE MATERIALS FROM SCRAP AND RETIRED MAINTENANCE OF WAY AND STRUCTURE MACHINES, TOOLS AND APPLIANCES, COLLABORATING WITH DIVISION VI, PURCHASES AND STORES, A.R.A.

J. R. Watt, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, H. W. Brown, J. J. Desmond, F. S. Hales, T. T. Irving, W. L. Roller, G. L. Sitton, J. G. Wishart.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year.

Appendix N

(13) STANDARD WHEEL FLANGES, TREADS AND GAGES, COLLABORATING WITH THE MECHANICAL DIVISION OF THE A.R.A. AND THE ASSOCIATION OF MANUFACTURERS OF CHILLED CAR WHEELS

C. J. Geyer, Chairman, Sub-Committee; C. R. Harding, C. A. Alden, E. W. Caruthers, J. V. Neubert, G. A. Peabody, J. B. Strong.

This subject has been under discussion for several years. At the last convention, March, 1932, Plan No. 790, dated September, 1931, was presented with the idea of having it adopted; but discussions developed the advisability of some changes and it was therefore offered as information only. This plan has now been revised and amplified for clarity, and to more comprehensively cover the subject.

The data collected and field measurements taken on this subject and references to conferences held are outlined in the Committee's report for last year, published in the 1932 Proceedings, Vol. 33, page 586, and discussions on the subject will be found on pages 818 and 819 in the 1932 Proceedings. The data already presented will not be repeated here, but the following summary is now submitted.

With 4 ft. 8½ in. gage and 1¾ in. flangeways the clearance for cast chilled wheels and for large-flange locomotive wheels is approximately ⅛ in. on the gage side and practically nothing on the guard side, especially when wheels are tread worn. The plan now presented recommends, for New Work, flangeways 1⅞ in. wide, with tolerances nothing over and 1/16 in. under, and maximum guard face gage in crossings 4 ft. 4⅞ in. For Maintenance the frog and crossing limit gage as outlined is recommended.

This subject is now considered more important than heretofore, because heavier rails and more rigid track structures are now used, particularly in new work. In lighter rail work and in worn track there is a degree of flexibility, which cannot be counted upon in new heavy-rail trackwork of rigid construction. Furthermore, the elimination of track distortion will add to the life of trackwork fixtures; consequently there should be a considerable saving in maintenance costs with track maintained within the limits specified on the plan now presented.

Revisions for existing frog and crossing plans, to conform to Plan No. 790, are outlined in 1933 Index Supplement, pages 4, 5, and 6, presented in Appendix A. If these revisions are approved, it is the intention to incorporate them on the plans affected, thereby avoiding confusion by making it unnecessary to refer to the Index Supplement for the revisions specified.

Conclusions

The Committee recommends that

Plan No. 790, dated Revised Nov. 1932, A.R.E.A. Data for Gages and Flangeways at Frogs and Crossings, showing Limits where Gage is not Widened for Curvature,

submitted herewith, be adopted as recommended practice and printed in the Manual.

Appendix O

(14) DAMAGE FROM BRINE DRIPPINGS, COLLABORATING WITH MECHANICAL DIVISION, A.R.A.

W. G. Arn, Chairman, Sub-Committee; G. M. Strachan, J. G. Wishart.

The Committee, collaborating with a sub-committee representing the Mechanical Division, A.R.A., on this subject, decided that committee representing the Mechanical Division will endeavor to get authority to make a detailed inspection of refrigerator cars with brine tanks similar to and to compare with such an inspection as was made some four years ago, as a basis for formulating further action, if any, in regard to improving the efficiency of the brine retaining devices.

The Mechanical Sub-Committee report that there are about 160,000 of the open bunker type of cars used mainly for fruit and vegetables on which there is no device for retaining the water from the melted ice; that for 75 per cent of the time that these cars are in service they are used with only air-cooling or ventilation, no ice being used. In only 25 per cent of the service is ice used; and in only 8 per cent of this 25 per cent is salt used; so that of the open bunker type of cars only 2 per cent of the total number in service are cars which drip brine. In these cars the amount of salt varies from about 3 per cent to 15 per cent of the amount of ice. They claim therefore that the damage on account of brine drippings from these cars is not enough to justify the very heavy expense which would be involved to equip these cars with some kind of a brine retaining device. It is estimated that at the very least it would cost $300.00 per car, or $48,000,000; and that cars so equipped would require increased inspection and maintenance, and would probably be less satisfactory to the shippers than the cars in their present condition.

The replies to the last questionnaire sent out to ascertain the amount of damage from brine drippings indicated that only ten railroad systems in the United States and Canada were seriously damaged by brine drippings, and that the total damage per year was about $2,100,000.00. A few of the roads reported very heavy damage; and one road —the Pennsylvania—which probably suffers considerable damage, did not make a report. Assuming therefore that the $2,100,000.00 estimate is correct, this amount capitalized at 5 per cent would be equal to $42,000,000.00, indicating that the expense of equipping the open bunker type of cars with brine retaining devices is not justified, particularly so as these cars are responsible for only a part of the brine drippings.

Conclusion

It is recommended that this report be received as information.

REPORT OF COMMITTEE II—BALLAST

A. P. CROSLEY, *Chairman;*
CLARENCE BAKER,
D. C. BARRETT,
G. J. BELL,
W. E. COLLADAY,
C. J. COON,
M. I. DUNN,
H. F. FIFIELD,
W. L. FOSTER,
J. J. GALLAGHER,
A. T. GOLDBECK,
C. G. GROVE,
DANIEL HUBBARD,
A. A. JOHNSON,
A. D. KENNEDY,
O. N. LACKEY,
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W. W. PATCHELL,
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C. P. RICHARDSON,
H. M. RIGHTER,
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W. J. SHAW, JR.,
C. B. STANTON, *Vice-Chairman;*
A. B. SHIMER,
J. A. SNYDER,
J. W. STONE,
H. E. TYRRELL,
STANTON WALKER,
J. B. WILSON,
A. H. WOERNER,
A. O. WOLFF,
C. H. ZENTMYER,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report on the following subjects:

1. Revision of Manual.
2. Specifications for prepared gravel ballast, including best method of testing for hardness, abrasion, and resistance to weathering (Appendix A).
3. Specifications for stone ballast, including best method of testing resistance to weathering (Appendix B).
4. Comparative costs of maintaining track on various kinds of ballast (Appendix C).
5. Effects of different kinds of ballast on life of ties, on life of rail and upon rail failures, particularly as between gravel and crushed stone ballast (Appendix D).
6. Determine proper depth and kind of sub-ballast (Appendix E).
7. The effect of better and deeper ballast on the cost of lining and surfacing (Committee reports progress).

Action Recommended

1. Changes are covered in Appendix D.
2. That Appendix A be accepted as a progress report.
3. That Appendix B be accepted as a progress report.
4. That the report appearing as Appendix C be accepted as information.
5. That the report appearing as Appendix D be accepted as a progress report.
6. That the revision as recommended in Appendix E be approved.

Respectfully submitted,

THE COMMITTEE ON BALLAST,
A. P. CROSLEY, *Chairman.*

Bulletin 352, December, 1932.

Appendix A

(2) SPECIFICATIONS FOR PREPARED GRAVEL BALLAST, INCLUDING BEST METHOD OF TESTING FOR HARDNESS, ABRASION AND RESISTANCE TO WEATHERING

C. B. Stanton, Chairman, Sub-Committee; Clarence Baker, W. L. Foster, J. J. Gallagher, O. N. Lackey, W. A. Roderick, S. A. Seely, Stanton Walker, A. H. Woerner, A. O. Wolff.

Last year's report referred to information which had been collected to serve as a guide in carrying out the assignment of the Sub-Committee, but which opportunity had not been had to study. During the present year conditions have not been favorable for the collection of additional information but work has been done in considering the data previously secured. That information consists of test results on samples of gravel ballast and of the results of two questionnaires as follows:

(1) On the extent to which the present specification of the Association for prepared gravel ballast is being used.

(2) On the service record in the roadbed of specific gravels on which detailed laboratory tests have been carried out.

The replies to these questionnaires are fairly complete, but the studies of them which have thus far been carried out do not lead to any very definite conclusion. It is believed, however, that it will be of interest to summarize the information obtained even though the summary cannot be accompanied by definite recommendations.

The results from the first questionnaire, on the extent of the use of the Association's specification, are summarized in Table 1. The questionnaire was submitted to 110 railroads representing approximately 253,000 miles of line and replies were received from 50 roads operating about 165,000 miles. The returns, therefore, represent about 65 per cent of the mileage covered. Of the roads replying, 68 per cent of the mileage indicated the use of prepared gravel ballast, and 10 per cent the use of pit run.

On the question of the use of the Association's specification, an answer was received from only 72 per cent of the mileage returning the questionnaire. Of this mileage, 44 per cent indicated that the Association's specification as written, or of requirements based on them, are used. An equal percentage indicated the use of some type of specification. Only 12 per cent reported the use of no specification. Approximately 45 per cent of the mileage returning the questionnaire replied to a request for suggestions for changes in the present specification. Of this, 85 per cent stated that they had no suggested changes to offer and 15 per cent suggested changing the Association's specification to those used by the individual railroad. A question with reference to the feasibility of obtaining conformity to the specification in use elicited replies from 51 per cent of the mileage returning the questionnaire, which were unanimous in indicating that no difficulty was encountered in this respect.

Each of the railroads was requested to furnish the grading specification under which they purchased prepared gravel ballast and 40 per cent of the mileage returning the questionnaire furnished information of this nature. Due to the differences in form of grading specifications used, it has been difficult to summarize this information clearly. For example, specifications stated in terms of percentages retained between different sieves are not translatable to terms of total percentages passing each sieve. An approximate translation can be made, however, and in Fig. 1 the grading requirements of the different railroads have been expressed in terms of total percentages passing the various

sieves—the form used in the Association's specification. It will be noted from this diagram that certain of the railway specifications contained inadequate information to permit of representing the limits diagrammatically; it is believed, however, that the intent of these specifications will be clear.

When the wide differences in local conditions are taken into consideration, it is felt that the replies to the questionnaire have shown a satisfactory approval of the Association's specification. The Sub-Committee is encouraged in the belief that the specifications are in a form practical of application to the needs of all railroads, although it recognizes the desirability, in some instances, of individual roads introducing modifications to suit local conditions.

The results of the questionnaire on the service records of specific gravels on which laboratory tests have been carried out are summarized in Table 2. In last year's report the hope was expressed that a study of these results, in connection with the data of the laboratory tests, would lead to definite recommendations for specification limits covering hardness, resistance to abrasion, resistance to weathering, and other factors not included in the present specification. Studies thus far carried out do not permit the Sub-Committee to make definite recommendations in this respect.

A comparison of the summary shown in Table 2 with data of the source, nature and laboratory tests of the samples reported in Vol. 31, pages 764 and 765, and in Vol. 33, pages 351 and 352, will serve to illustrate the difficulties encountered by the Sub-Committee in arriving at definite conclusions. For example, it seems impossible to deduce any definite relationship between the resistance to abrasion and reports on the resistance to breaking down under traffic and tamping; the gravel on which the least favorable report was given had a resistance to abrasion about the mid-point of all of the samples tested. Similarly, consideration of the specific gravity in connection with this factor shows no relationship; the gravel with the least favorable report had a specific gravity somewhat higher than the average. A like lack of relationship was shown in the case of the absorption tests. A vague relationship is discernible in the case of the crushing test, although it is by no means definite; in general, those gravels showing the lowest reductions in voids and fineness modulus in the crushing test received the most favorable reports on resistance to breaking under traffic and tamping. It should be emphasized, however, that all of the gravels considered were of fairly high quality; none of them gave very poor results in the laboratory tests and all received quite favorable reports concerning their resistance to breakage in the track.

The replies to the question relative to the durability, or resistance to disintegration due to weathering, represents the principal additional item of information from the questionnaire which permits of correlation with the laboratory tests. Here again the relatively narrow range in quality of materials handicaps the drawing of definite conclusions. The sodium sulfate soundness tests show no relationship to the service reports. In fact the aggregate showing the greatest disintegration in the sodium sulfate test received a report on its service which stated "very little disintegration due to weather," in spite of the fact that it was used in a relatively severe climate. On the other hand, one of the samples giving among the better results in the sodium sulfate test received the report "disintegrates after about three or four years' exposure to weather; liable to cause churning joints and caking in dry weather." Such inconsistencies do not appear for all of the samples, but they will serve to illustrate the Sub-Committee's inability to draw definite conclusions. Particular attention is directed to the geographical locations (and, therefore, the severity of climatic conditions) of the sources of the gravels tested and of the roads using them.

In view of the lack of correlation between the laboratory and field results, the Sub-Committee does not feel justified in completing its assignment at this time. Present information does not seem to permit of more than guesses at suitable limits on abrasion, specific gravity, absorption, etc. It is believed that further study should be given to the crushing test. The sodium sulfate soundness test not only fails to show a relationship to durability in the track, but investigations of this test method during the past year indicate the likelihood that major changes in the procedure for it may be recommended within the comparatively near future. Future tests of the nature of those carried out should pay special attention to samples representing a wider range in quality than those which have been tested. Instead of testing samples and then determining their service record, it is believed that future activities should be along the lines of examining materials which have shown some abnormalities in service record.

The Sub-Committee submits the foregoing as a progress report.

TABLE 1

SUMMARY OF QUESTIONNAIRE ON USE OF ASSOCIATION'S SPECIFICATIONS FOR PREPARED GRAVEL BALLAST

Questionnaire sent to 110 railroads representing 253,010 miles; replies received from 50 railroads representing 164,919 miles or 65.3 per cent of total

Question No.	*Question*	*Percentage of Mileage Represented by Replies* — *Mileage Returning Questionnaire*	*Total Mileage Questioned*
1.	Is your railroad using prepared gravel ballast?		
	Yes	67.7	44.2
	No	21.8	14.2
	Pit run	10.5	6.9
2.	Are the Association's specifications in use?		
	Yes	5.7	3.7
	Based on A.R.E.A.	25.3	16.5
	No (Railroad's own)	31.8	20.7
	No specifications	9.4	6.2
3.	Are the tests recommended being used?		
	Yes	13.9	9.1
	No	13.3	8.7
	In part	22.6	14.7
4.	Are tests in use other than those contained in the specifications?		
	Yes	25.3	16.5
	No	17.2	11.2
5.	What changes do you suggest in the Association's specifications?		
	None	38.1	24.8
	Railroad's own	7.1	4.6
6.	Does your railroad experience difficulty in obtaining conformity to their specifications?		
	No	51.1	33.2
	Yes	0.0	0.0
7.	Please furnish a copy of the specifications upon which your road buys prepared gravel ballast and a description of the tests required.		
	Answers received	40.0	26.0
	(See Fig. 1 for summary of gradings)		

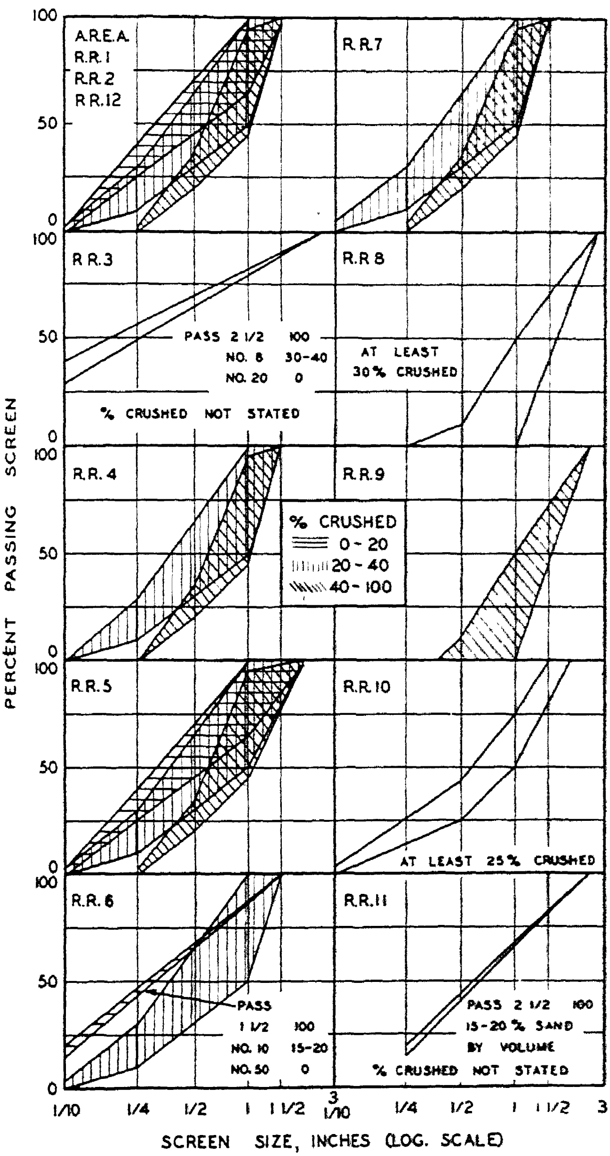


FIG. 1.—Comparison of Grading Requirements for Prepared Gravel Ballast of Different Railroads with A.R.E.A. Specifications

Appendix B

(3) SPECIFICATIONS FOR STONE BALLAST, INCLUDING BEST METHOD OF TESTING RESISTANCE TO WEATHERING

J. M. Podmore, Chairman, Sub-Committee; D. C. Barrett, C. J. Coon, H. F. Fifield, W. L. Foster, A. T. Goldbeck, W. W. Patchell, H. M. Righter, A. B. Shimer.

At the 1931 convention, your Committee presented a revised and rearranged set of specifications for stone ballast, which were approved. Slight modifications were suggested, principally for clarity's sake, at the 1932 convention, and these were approved. Your Committee has kept these specifications constantly before them with the thought of keeping them up-to-date in the light of new methods of test which are being recommended and which hold some promise of assisting in test methods. Your Committee does not recommend any changes at this time, but calls attention to the fact that additional information is available on certain test methods.

Section 18 of the specifications, Apparent Specific Gravity, further information may be obtained by referring to A.S.T.M. Standard D 30-18.

Section 21, Toughness, further information is given in A.S.T.M. Standard D 3-18.

Your Committee desires to call attention to Section 22, Wear Test. The present specification calls for the test to be made on ledge rock from the quarry using hand broken fragments. In other words, the present test provides only for testing ledge rock. Your Committee has prepared an alternate specification for making test on crushed stone as produced for ballast known as the Modified Abrasion Test. Your Committee is submitting this as information and criticism with the thought of recommending it for adoption at some later date. It seems to your Committee that when selecting samples from a quarry in operation that the samples should be taken from the prepared stone ballast instead of from a quarry ledge or face which is rarely representative as it has not been subjected to the effects of crushing and screening operations, through which the prepared stone passes.

The Modified Abrasion Test is as follows:

> "A representative portion of the crushed stone used in making ballast shall be screened to yield these sizes and weights of material—twelve hundred and fifty (1250) grams between each of the following pairs of round opening screens: 2″–1½″, 1½″–1″, 1″–¾″. These fractions are combined, washed, dried thoroughly, weighed and placed in the abrasion machine with 6 cast iron spheres 1.875 inches in diameter and weighing approximately 0.95 lb. (0.45 kg.) each. The charge is then revolved at the rate of 30 to 33 revolutions per minute for 10,000 revolutions for each test, after which the pieces shall be thoroughly washed, dried and weighed and the percentage of dust or detritus by weight that will pass through a screen with 1/16 in. (0.16 cm.) openings shall be considered the loss by abrasion. Rock that has a greater percentage of abrasion than ...... shall be rejected."

(American Association of State Highway Officials T. 4) modified.
Ohio State Highway Specifications 1932 p. 201.
A.S.T.M. D 289-28T modified for stone.

Last year your Committee recommended that the sections dealing with Cementing Value be removed from the specifications for reasons given at that time. By direction of the convention, the Committee was directed to give this further study. A questionnaire has been sent out to ascertain the number of roads actually embodying this feature in their specifications in the purchase of stone ballast and the extent to which it is being used. Replies were not received in time to permit inclusion in this year's report.

Recommendation

That the report be received as information.

Appendix C

(4) COMPARATIVE COSTS OF MAINTAINING TRACK ON VARIOUS KINDS OF BALLAST

Daniel Hubbard, Chairman, Sub-Committee; J. J. Gallagher, A. D. Kennedy, H. M. Long, J. A. Snyder, A. H. Woerner, C. H. Zentmyer.

Last year your Committee submitted some data on costs of maintaining track on gravel and stone ballast. Same may be found in Vol. 33, page 359 of the Proceedings. The data covered the years 1927 to 1930 inclusive. This year's data is given in the accompanying tables for the year 1931. Your Committee is arranging to have samples of the gravel and stone ballast analyzed in the laboratory as a check on field performance. It should be noted that gravel is being used to replace the original stone ballast so that the possibility of securing additional information is rather doubtful.

Some information has been secured from another road but opportunity has not been had to attempt to get it in shape for presentation.

It is recommended that the information be accepted as a progress report.

TABLE 1

THE NORTH AND SOUTH RAILWAY COMPANY
STANDARD MILE—BETWEEN MILEPOST 625 AND 626
GRAVEL BALLAST

EAST DIVISION — WEST DISTRICT

1931

	Units	*Man Hours*	*Unit Cost*	*Mat'l Cost*	*Labor Cost*	*Total Cost*
Ties—Digging In	89	104	1.19	105.91	45.47	149.38
Ties—With Raise						
Ties—Switch	81	20	.224	17.90	8.36	26.26
Ties—Plates						
Rail Joints						
Ballast Stone						
I&S Main Track	25650	1253			523.76	523.76
Respacing Ties	150	8			3.34	3.34
Regaging Ties						
T&R Bolts	962	18	.08	.16	7.52	7.68
Guard Rails						
Banking	600	108		30.00	45.14	75.14
Ditching	550	30			12.54	12.54
Cleaning Right-of-Way	23311	352			147.14	147.14
Mowing	21120	118			49.32	49.32
Weeding						
Tapping Spikes						
Repairing Crossings	5	97		21.35	40.55	61.90
Snow and Ice	26	21			8.78	8.78
Superficial Dressing						
Oiling Bolts	2160	14	.08	.96	5.85	6.81
Spikes						
Patrolling	2	263			109.93	109.93
Miscellaneous		16			6.68	6.68
Salvage						
Total		2422		176.28	1012.38	1188.66
Av. Hourly Rate .415						....

TABLE 2

THE NORTH AND SOUTH RAILWAY COMPANY
STANDARD MILE—BETWEEN MILEPOST 581 AND 582
STONE BALLAST

WEST DIVISION EAST DISTRICT

1931

	Units	Man Hours	Labor Cost	Mat'l Cost	Total Cost
TIE RENEWALS					
Digging in each					
With Raise—each	366	187	78.42	494.78	573.20
Switch—lin. ft.	221	26	10.90	8.51	19.41
RAIL RENEWALS					
New	5533	922	386.62	3688.07	4074.69
Repair					
OTHER TRACK RENEWALS					
Tie Plates	1735	195	81.77	173.50	255.27
Rail Joints					
Frogs	2	23	9.64	99.23	108.87
Miscellaneous		71	29.77	25.00	54.77
BALLAST					
Cleaning—Yard	279	864	362.30		362.30
Stone—Yard					
Gravel—Yard	10577	2285	958.16	972.00	1930.16
LINE AND SURFACE					
Main Track—ft.	13695	808	338.82		338.82
Respace Ties	2121	229	96.03		96.03
Regaging Ties	2402	185	77.58	4.82	82.40
Tighten Bolts	1770	31	13.00	3.09	16.09
ROADWAY					
Banking—ft.	2351	376	157.67		157.67
Ditching—ft.	1880	234	98.12		98.12
Cleaning	40399	498	208.83		208.83
Mowing		181	75.90		75.90
Repair Switches		73	30.61	5.00	35.61
Oil Joints	600	19	7.98	1.00	8.98
Snow and Ice		9	3.77		3.77
Patrolling		213	89.32		89.32
Undistributed		114	47.80		47.80
Total		7543	3163.01	5475.00	8638.01
Av. Hourly Rate .41933					

Appendix D

(5) EFFECTS OF DIFFERENT KINDS OF BALLAST ON LIFE OF TIES, ON LIFE OF RAIL, AND UPON RAIL FAILURES, PARTICULARLY BETWEEN GRAVEL AND CRUSHED STONE BALLAST

M. I. Dunn, Chairman, Sub-Committee; Clarence Baker, A. T. Goldbeck, A. A. Johnson, W. W. Patchell, A. B. Shimer, J. A. Snyder, Stanton Walker.

This is a new subject. It is apparent that a large number of factors will have to be taken into consideration before an attempt is made to formulate a comparison between the effects of different kinds of ballast on life of ties and rail.

In regard to effect of ballast on life of ties, it is only necessary to consider tie damage done by wheel load and impact, the Sub-Committee having no evidence of appreciable acceleration or retardation of decay arising from use of different kinds of ballast, provided sufficient clean ballast is used to insure drainage of ballast section.

Damage to ties that may be partly caused by ballast, falls into the following classes:

1. Indentation by ballast under heavy traffic.
2. Rounding of bottom surface due to churning of tie in ballast.
3. Splitting of tie due to wedge action of ballast in cracks.
4. Injury due to tamping tools.
5. Breaking of tie ends due to spot surfacing.
6. Breaking of ties between rails due to centerbinding track.

It is our experience that on heavy traffic main tracks, as between gravel and crushed stone, the degree of these different kinds of damage may be graded as follows:

	On Gravel	*On Stone*	*Remarks*
1. Indentation	Slight	Excessive	Reaches 1½" in hardwood ties on stone ballast.
2. Rounding	Very Pronounced	Slight	Gravel ballast does not interlock, and thus hastens abrasion of corners of tie.
3. Splitting	Slight	Pronounced	Gravel as a rule offers no wedge shaped fragments and is too resilient to wedge into cracks and does not offer the compacted striking block that stone does to hasten the splitting.
4. Tamping Bruises	Noticeable	Slight	Constant smoothing required on gravel.
5. Broken Heads	Slight	Pronounced	Spot surfacing and tendency to tamp heads only on stone when pulling joints, resulting in uneven bearing on adjacent ties.
6. Breaking between Rails	Pronounced	Slight	Stone is tamped only on head, and quarter of ties and will not tamp itself, while gravel will fill and tamp centerbound ties.

Without any means of evaluating the above classes of damage or statistics to back up such conclusion, it is felt from present information, a somewhat greater age will be attained by the average tie on stone ballast than on gravel ballast under identical roadbed, rail, and traffic conditions. Further study and investigation is to be made of the subject.

In regard to life of rail on different kinds of ballast, rail may be taken out of service for any of the following causes:

1. Inadequate original section.
2. Reduction of section by wheel wear.
3. Corrugation by wheel wear.
4. Detail fractures, split heads, bolt hole breaks, etc.
5. Sudden ruptures.
6. Mashed and battered ends.
7. Reduction of section by chemical action (rust, electrolysis, etc.).

Obviously, kind of ballast would have no bearing on causes for removal Nos. 1, 2 and 3.

The effect of different kinds of ballast on the formation of detail fractures and split heads is not apparent, but it may be said that bolt hole breaks are more apt to be found on gravel and other fine ballast than on stone, for the reason that stone ballast offers more rigid bearing to the joint. The same may be said of mashed and battered ends.

Reduction of section due to rust and electrolysis is limited to rail on cinder in general, and such reduction is accelerated by use of rail as ground for electrical locomotives, or other equipment. When cinder ballast is used under rail that serves as ground or return side of circuit, the cinder should be kept below the base of rail. Causes have been observed where base of rail has been reduced as much as ⅜ inch by electrolysis.

A checkup of broken rail report data on two trunk line railways showed that by far the largest number of sudden ruptures occurred on stone, as opposed to gravel ballast. In fact, certain branches are known to operate for years without any broken rails on gravel ballast.

However, on looking further into this data, it was revealed that the heavier traffic main lines of both railways were on stone. The new rail was largely laid on these stone ballast lines, and broken rails due to transverse fissures was frequent because the majority of rail was put in service on these lines when new. On the lighter gravel ballasted lines, a larger percentage of the rail was relay, and had been tested out on the heavy traffic stone ballast territory, where any inherent flaws which cause sudden rupture would be brought to light, and defective heats could be weeded out.

Further study of broken rail records of a larger number of roads will have to be made before any definite conclusion may be reached.

Recommendation

That the above report be received as information.

Appendix E

(6) DETERMINE PROPER DEPTH AND KIND OF SUB-BALLAST

A. D. Kennedy, Chairman, Sub-Committee; C. G. Grove, J. M. Podmore, C. P. Richardson, S. A. Seely, J. W. Stone, H. E. Tyrrell, C. H. Zentmyer.

The Sub-Committee in studying this subject, submitted to the railroads of the United States and Canada a questionnaire which is given in detail in Appendix E of the Committee's report for 1932, together with a summary of the replies denoting consensus of opinion.

From the replies received, the Committee concludes that many materials such as stone screenings, pit run gravel, cinders, slag, sand, etc., are used for sub-ballast with satisfactory results, and that, undoubtedly, the availability of supply generally determines both the depth and kind of material to use. Therefore, no recommendation is being made regarding the relative merits of certain limits, materials of smaller aggregates are to be preferred, for such materials have a greater tendency to prevent roadbed materials working up into the top-ballast, which is one of the principal functions of a sub-ballast.

Due to the many factors that must be considered, such as the nature of the roadbed, the total depth of ballast, section, character of track, volume and nature of traffic, etc., the Committee finds it impracticable to determine definitely the proper depth of sub-ballast, but is of the opinion when the top-ballast consists of large and sub-ballast of

small aggregates, a combination of top-ballast and sub-ballast of a ratio to be governed by local conditions will give better results than if top-ballast material were used for the entire depth of the ballast section.

The Committee, in reviewing this subject, finds it advisable to recommend certain revisions in the 1929 Manual, as follows:

1. Definition of Sub-Ballast: To change the present form appearing on page 93, which reads: "Any material of a superior character which is spread on the finished sub-grade of the roadbed and below the top-ballast to provide better drainage, prevent upheaval by frost and better distribute the load over the roadbed," to read: "That portion of the ballast next to the sub-grade—a strata of material superior in character to that in the sub-grade and placed next to it to give a better foundation for the top-ballast; provide better drainage and a more uniform distribution of the load over the roadbed, acting as a cushion between the top-ballast and the roadbed, thereby retarding the action of the roadbed material from working up into the top-ballast."

2. To change paragraph 4 under the heading "Proper depth of ballast," on page 102, which reads: "A combination of a good sub-ballast 18 to 14 in. and top-ballast 6 to 10 in., making a total of approximately 24 in. under the tie in the aggregate will produce nearly the same result as though the superior material was used for the full depth," to read: "A combination of a good sub-ballast and top-ballast (the ratio of the one to the other being dependent upon local governing conditions) will produce better results than a superior material used for the full depth. The total depth in the aggregate of 30 in. or more below the bottom of tie may be required."

3. To change captions on pages 103 and 104, which read: "Ballast Sections with Particular Reference to Sub- and Top-Ballast, Class 'A' sections should have 24 inches of ballast under the tie" to read: "Typical Stone Ballast Sections with Particular Reference to Sub- and Top-Ballast, Class 'A' track should have 24 inches of ballast under the tie," to read: "Typical Stone Ballast Sec- heading: "Proper Depth of Ballast."

4. To change caption on page 105, which reads: "Ballast Sections for Gravel Ballast on Class A Roads, Depth of Ballast 24 inches," to read: "Typical Gravel Ballast Sections with Particular Reference to Sub- and Top-Ballast, Class 'A' track should have 24 inches of ballast under the tie" or as modified in paragraph 4 under heading: "Proper Depth of Ballast."

Recommendation

That the above revision of the Manual be adopted.

REPORT OF COMMITTEE XXI—ECONOMICS OF RAILWAY OPERATION

J. E. TEAL, *Chairman;*
B. T. ANDERSON,
R. C. BARDWELL,
S. B. COOPER,
G. S. CRITES,
H. C. CROWELL,
OLIVE W. DENNIS (MISS),
L. F. DERAMUS,
W. N. DERAMUS,
J. H. DYER,
S. W. FAIRWEATHER,
J. M. FARRIN,
Z. A. GREEN,
G. W. HAND,
E. M. HASTINGS,
E. L. HOOPES,
W. W. HOUSTON,
C. H. R. HOWE,
G. D. HUGHEY,
W. W. JUDSON,
E. E. KIMBALL,
SHU-T'IEN LI,
M. K. LINGLE,
M. F. MANNION,
F. H. MCGUIGAN, JR.,
P. J. NEFF,
J. A. PARANT,
E. S. PENNEBAKER,
L. S. ROSE,
J. E. SAUNDERS,
J. F. PRINGLE, *Vice-Chairman;*
MOTT SAWYER,
R. T. SCHOLES,
B. J. SCHWENDT,
W. C. SLOAN,
C. E. SMITH,
H. W. SNYDER,
C. H. STEIN,
M. F. STEINBERGER,
R. E. VAN ATTA,
BARTON WHEELWRIGHT,
C. C. WILLIAMS,
JOHN WORLEY,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents report covering the following subjects:

2. Methods for obtaining a more intensive use of existing railway facilities, with particular reference to securing increased carrying capacity.

(a) Without material additional capital expenditures.

(b) With due regard to reasonable increases in capital expenditures consistent with traffic requirements.

Report under this assignment is presented as Appendix A, and it is recommended that it be received as information.

5. Methods for determining most economical train length, considering all factors entering into transportation costs, collaborating with Division I—Operating, A.R.A.

Report under this assignment is presented as Appendix B, and it is recommended that it be received as information.

Progress is reported on the following subjects:

1. Revision of Manual, including revision of the method for the determination of proper allowances for maintenance-of-way expenses due to increased use and increased investment.

3. Methods or formulas for the solution of special problems relating to more economical and efficient railway operation.

4. Most economical makeup of track to carry various traffic densities, collaborating with Committees I—Roadway, II—Ballast, III—Ties, IV—Rail, V—Track and X—Signals and Interlocking.

6. The effect of volume of traffic on railway operating expenses, collaborating with Committee XXII—Economics of Railway Labor.

7. Discontinuance of non-paying trains and agencies, rendered so by all forms of highway competition.

8. Operation with reduced number of main tracks.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY OPERATION,
J. E. TEAL, *Chairman.*

Bulletin 353, January, 1933.

Appendix A

(2) METHODS FOR OBTAINING A MORE INTENSIVE USE OF EXISTING RAILWAY FACILITIES, WITH PARTICULAR REFERENCE TO SECURING INCREASED CARRYING CAPACITY:

(a) Without material additional capital expenditures.
(b) With due regard to reasonable increases in capital expenditures consistent with traffic requirements.

M. F. Mannion, Chairman, Sub-Committee; B. T. Anderson, R. C. Bardwell, J. H. Dyer, S. W. Fairweather, G. D. Hughey, E. E. Kimball, L. S. Rose, B. J. Schwendt, R. E. Van Atta, Barton Wheelwright.

FORECAST OF IMPROVEMENT IN TRAIN OPERATION ON A SINGLE TRACK RAILROAD EQUIPPED WITH SHORT SECTIONS OF DOUBLE TRACK WITH SPRING SWITCHES AND C.T.C. CONTROLLED MANUAL BLOCK

History

During the past few years this Committee has presented reports covering the effect of various changes in operating conditions upon freight train performance, embracing the effect on freight train performance of:

(1) the number of trains per day, (2) length of engine district, (3) double tracking, (4) passenger train operation, (5) supervision, (6) substituting heavy steam power for light, (7) installing automatic signals, (8) centralized traffic control and (9) converting double track into single track.

The study covering the effect of centralized traffic control on train performance was presented in 1930, and covered the first complete installation of signal dispatching whereby trains were operated by signal indications on single track without written train orders or timetable superiority. This year the Committee submits a report which forecasts the economies that may be expected by the installation of a modified centralized traffic control system for controlled manual block operation of a single track railroad equipped with short sections of double track with spring switches.

Description

The North and South Railroad was built a number of years ago for the purpose of opening up a territory rich in virgin timber and coal deposits. The main operating division of this line extends from a classification yard to two assembling yards about 100 miles and 123 miles distance, respectively. Traffic moves into the assembly yards from various branch lines. In addition to mines located above the assembly yard, there are a number of mines intermediate between the assembly yard and the classification yard, which has a substantial bearing upon the freight train operation on this division.

The track plan and profile of this engine division is shown on Fig. 1. An analysis indicates that there are 123 miles of first main track; 35 miles of second track, which is distributed in four sections; 11 passing sidings of 110 car capacity and under 140 car capacity, and 4 passing sidings of 140 car capacity and over. Of the second track mileage, 23.6 miles were put in operation since 1924, including 20.2 miles in 1925, 3.3 miles in 1929, and 0.1 mile in 1930. The ruling grade adverse to loads is .25 per cent. 46 per cent of the mileage has either level or adverse grades to traffic, of which 17.3 per cent has grades up to .25 per cent, and 8.3 per cent has short grades up to 1.00 per cent. 62.2 miles are curved and 60.9 miles are straight. There are 58 curves in excess of 6°, 26 between 6° and 7°, 12 between 7° and 8°, 13 between 8° and 9°, and 7 between 9° and 11°. 49.2 per cent of the rail is 100-lb. and 50.8 per cent is 130-lb.

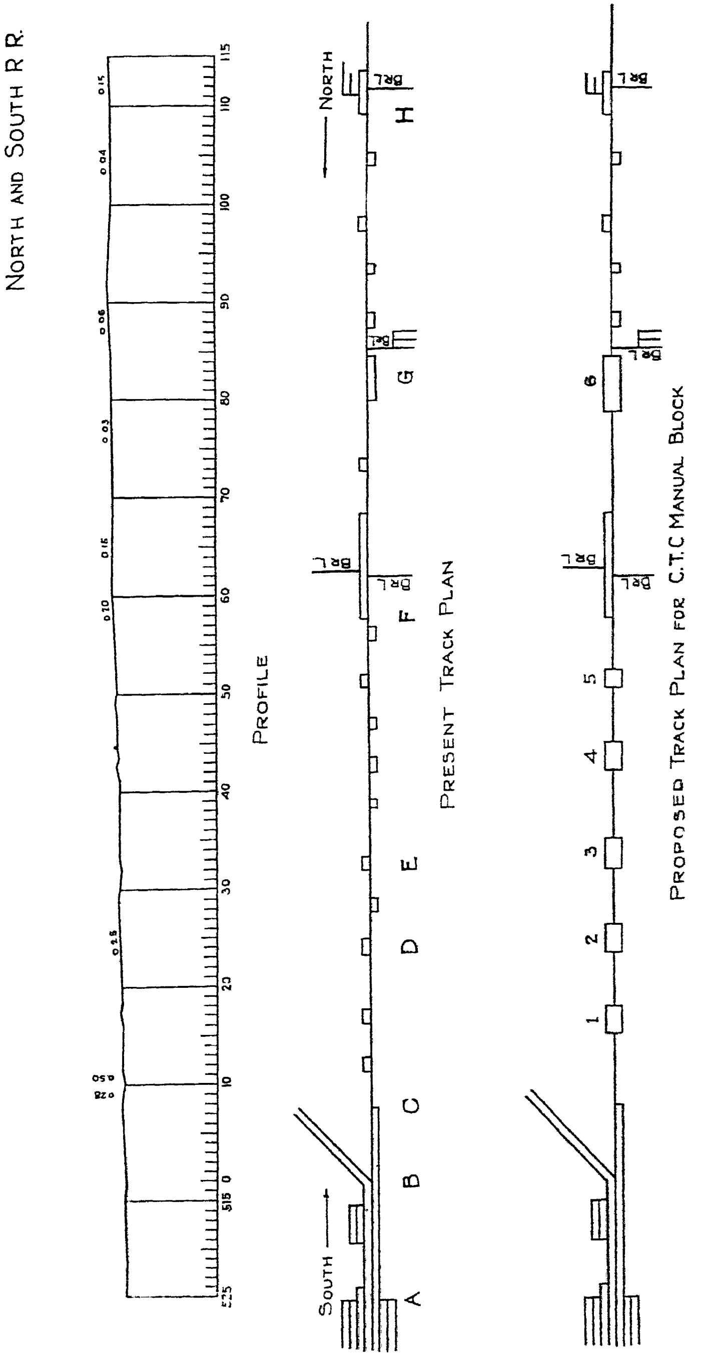

North and South R.R.
Profile
North
South
A
B
C
D
E
F
G
H
Present Track Plan
1
2
3
4
5
6
Proposed Track Plan for C.T.C Manual Block

Fig. 1.

Train Service

There are four classes of trains operated on this line, i. e., passenger, time freight, slow freight, and local freight. Two local passenger trains are operated in each direction daily. Normally two time freights are operated in each direction daily. The number of slow freight trains varies with the volume of traffic. One local freight is operated each way daily except Sunday.

Power

Time freight trains are operated with mikado type locomotives, with booster, having a tractive effort of 74,700 lb. Both mallet type and mikado type locomotives are used in handling slow freight trains. The mallet type locomotives have a tractive effort of 74,400 and 77,900 lb. Prior to November, 1931, both time and slow freight trains were operated with mallet locomotives. The mallet locomotives are equipped with engine tanks having 12,000 gallons capacity and the mikados are equipped with engine tanks having 16,000 gallons capacity.

Operation of Trains

Referring to Fig. 1, trains are operated at the present time between "A" and "B" by timetable, train orders and automatic block signals; between points "B" and "H" trains are operated by timetable, train orders and manual block. The maximum speed between "B" and "H" is 45 miles per hour for passenger trains, 35 miles per hour for time freights, and 30 miles per hour for slow freights.

Table 1 shows average freight train performance daily for the years 1924 to 1932, divided northbound and southbound and total.

TABLE 1

	Northbound			*Southbound*			*Total*			
Year	*No. Trains Per Day*	*Train Load*	*Speed*	*No. Trains Per Day*	*Train Load*	*Speed*	*No. Trains Per Day*	*Train Load*	*Speed*	*Gross Ton Miles Per Day (1000)*
				TIME FREIGHT						
1924	3.0	1,470	11.4	1.8	2,525	11.0	4.8	1,872	11.2	1,048
1925	3.1	1,418	12.4	2.0	1,453	13.1	5.1	1,431	12.8	947
1926	2.1	1,663	13.8	2.0	1,594	13.4	4.1	1,628	13.6	913
1927	2.0	1,785	14.2	2.0	1,568	14.3	4.0	1,677	14.3	930
1928	2.0	1,753	17.1	2.0	1,591	17.3	4.0	1,672	17.2	929
1929	2.0	1,714	18.9	2.0	1,611	18.1	4.0	1,663	18.5	924
1930	2.0	1,374	20.0	2.0	1,409	20.8	4.0	1,392	20.4	773
1931	2.0	1,434	19.7	1.9	1,286	23.6	3.9	1,358	21.7	737
1932* ...	2.0	1,603	20.3	1.0	1,421	25.4	3.0	1,543	21.8	643
				SLOW FREIGHT						
1924	8.6	1,546	9.5	9.7	4,467	8.5	18.3	3,140	9.0	4,264
1925	7.5	1,514	10.2	8.5	4,764	8.9	16.0	3,247	9.6	5,350
1926	7.2	1,598	10.7	8.0	5,022	9.2	15.2	3,384	10.0	5,574
1927	6.7	1,744	10.6	7.6	5,496	9.5	14.3	3,730	10.1	5,757
1928	5.9	1,790	12.0	6.7	5,507	10.8	12.6	3,759	11.4	5,241
1929	6.0	1,835	11.7	6.8	5,619	10.3	12.8	3,838	11.0	5,442
1930	5.0	1,954	12.9	5.6	5,992	11.0	10.6	4,065	12.0	4,801
1931	3.6	2,136	13.3	4.1	6,464	11.5	7.7	4,432	12.4	3,808
1932* ...	2.3	2,362	15.5	3.4	6,528	13.7	5.7	4,923	14.3	3,173

* Nine months.

In addition to the above, 2 passenger trains were operated in each direction daily, and 1 local freight was operated in each direction daily except Sunday during the entire period.

The maximum traffic occurred in 1927 when 14.3 slow freight trains produced an average of 5,757,000 gross ton miles per day. The average speed of slow freight trains between terminals was 10.0 miles per hour. This traffic density was substantially maintained until 1930 when the traffic decreased on account of general business conditions. Additional second track and other improvements, installed between 1924 and 1929, were largely responsible for the increase in the average speed of slow freight trains from 9.0 miles per hour to 11.0 miles per hour. Studies were made for completing the second track, about 62 miles between points "C" and "G", estimated to cost over $5,250,000. This could not be justified and attention was then given to some other means of effecting improved operation with a less expenditure of capital, resulting in the study of re-arranging passing sidings to form short stretches of double track with spring switches and C.T.C. controlled manual block.

FACTORS TO BE CONSIDERED IN COMPARING THE PRESENT TRACK LAYOUT AND METHOD OF TRAIN OPERATION WITH THE PROPOSED TRACK LAYOUT AND C.T.C. CONTROLLED MANUAL BLOCK METHOD OF TRAIN OPERATION

It is apparent that in studying the effect of train operation under the two types of track layout, due consideration should be given to the following factors:

(1) Present and proposed track and signal layout.

(2) Expenditures necessary in connection with track changes.
- (a) Present traffic.
- (b) Future traffic.

(3) Effect of proposed track plan on
- (a) Track and other maintenance.
- (b) Taxes.
- (c) Train operation.
- (d) Cost of transportation.
- (e) Track capacity.

(4) Comparison of present and proposed methods of freight train movements.
- (a) Timetable, train orders, and manual block.
- (b) Timetable and C.T.C. controlled manual block.

(5) Annual savings and return on expenditures.

After the foregoing factors have been given due consideration and a summary has been prepared, a conclusion can be drawn as to the feasibility of the proposed change.

Present Track Layout

The section of track selected for this study to be changed for C.T.C. operation, as shown in Fig. 1, is between two main junction points "B" and "G" and covers a territory of approximately 84 miles. The present track layout on this portion of the line consists of 22 miles of double track and 62 miles of single track. The double track is divided into three sections, one extending south from the northerly junction point, a distance of approximately 8 miles, and one extending north from the southerly junction point, a distance of approximately 4 miles. The other double track section, consisting of approximately 10 miles, is located between Mileposts 58 and 68, in a territory where two branch lines connect to the main track and where considerable switching work is done. There are 14 passing sidings in the 62 miles of single track, varying in length from 1100 to 11,000 feet.

Train movements are handled by timetable and train order system with manual blocking, the blocks varying in length from 2 to 17 miles.

There are two small and one large interlocking plants in this territory, the large plant being located at the north end of the territory and the small ones at each end of the 10 miles section of double track, while at the other two ends of double track the switches are hand thrown and handled by the operators.

There are 12 block offices in this territory—

6 being operated 3 tricks per day
3 " " 2 " " "
3 " " 1 trick " "

PROPOSED TRACK AND SIGNAL PLAN

Proposed Track Layout

Fig. 2 shows the proposed track and signal plan which is based on the removal of 8 of the existing passing sidings, extending 5 to a length of approximately 3 miles each and converting them into double track, and extending the north end of present double track near Milepost 80, a distance of approximately 2 miles. The reason for providing the 3 mile sections of double track is to provide proper means for allowing 2 trains in the same direction to meet opposing traffic. There will be 8 double track sections in the 84 mile territory. This is being accomplished by requiring only approximately 6000 feet of additional track.

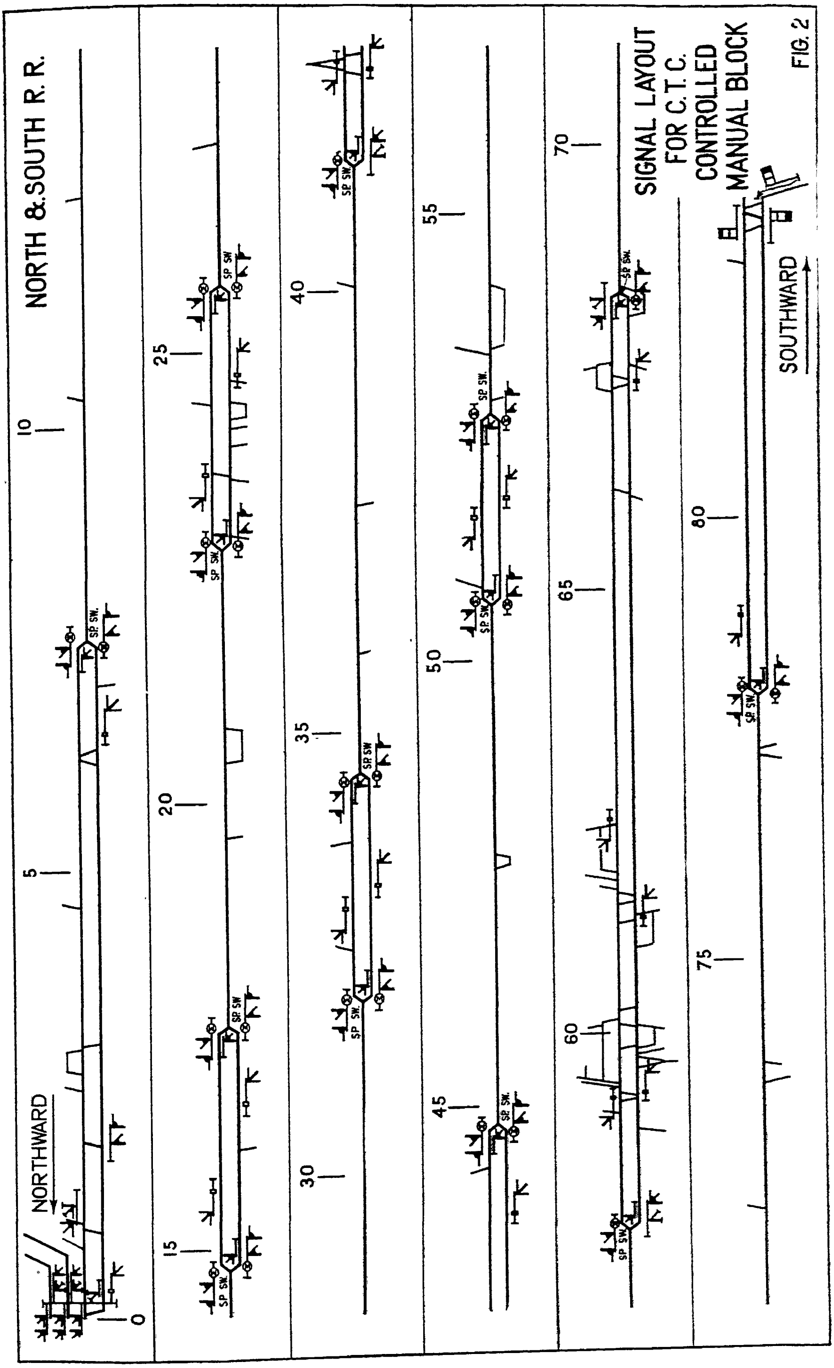
The proposed signaling includes:

1. Continuous track circuits throughout the entire territory.
2. Controlled manual block signals located at each end of the double track sections, except between Mileposts 58 and 68 automatic block signals will be used to protect two junction points and switching territory. The controlled manual block sections will vary in length from 3 to 7 miles.
3. Spring switches will be used at each end of the double track sections; except at a few locations where it may be found desirable to reverse traffic for expediting train movements, power operated switches will be provided.
4. Continuous OSing information will be furnished the dispatcher by providing forty-six OSing points in lieu of a maximum of twelve under present operation.
5. Signals will be of the color light type, the block signals displaying three indications, namely; stop, permissive, and proceed. The automatic signals will be of the 3 position type. An approach indication is provided for each controlled manual block signal governing movements into the single track sections.
6. The C.T.C. system is of the two wire code type, the control machine being located in the dispatcher's office, a distance of approximately 6 miles north of the northerly junction point of the 84 mile territory.

Under the C.T.C. system trains will be operated by signal indication superseding timetable and train order rights. The dispatcher establishes meeting and passing points as conditions require.

The system is so designed that proceed indication cannot be displayed on the controlled manual block signals unless the block is clear and all the switches are in proper position. Provisions are made, however, for allowing following movements in the same block by permissive indication. The system is designed so that neither proceed nor permissive indication can be given for opposing movements in the single track sections.

Normally, the movements on the double track sections will be with the current of traffic, except at certain locations where power operated switches are provided, reverse operation may be made by signal indication.



SIGNAL LAYOUT FOR C. T. C. CONTROLLED MANUAL BLOCK

FIG. 2

The modified C.T.C. system herein described was designed to provide for an economical system of train operation by signal indication for light traffic. It does not contemplate a complete installation at this time, however, it is so designed that additional automatic block signals, replacing controlled manual block signals can be added when, and as required by traffic conditions at minimum expense.

Expenditures Necessary in Connection with Track Changes

Table 2 shows the estimated cost of the proposed facilities aggregating $854,475 chargeable to A & B and $170,104 chargeable to Operation, or a total of $1,024,579. It is estimated that the proposed facilities will not only enable the handling of the present business more economically, but they will satisfactorily take care of any substantial increase in business which can be reasonably estimated for the future.

TABLE 2

ESTIMATED COST OF PROPOSED SIDE TRACK EXTENSIONS AND SIGNAL LAYOUT

	Direction	*Length*	*A & B*	*O E*	*Total*
"1"	North	6,800 L.F.	$133,720	$ 16,680	$ 150,400
"2"	South	5,000 "	145,250	11,770	157,020
"3"	"	7,800 "	123,500	7,350	130,850
"4"	"	6,000 "	109,920	9,150	119,070
"5"	"	5,400 "	101,510	7,200	108,710
"6"	North	10,800 "	123,600	6,400	130,000
Totals		41,800 L.F.	$737,500	$ 58,550	$ 796,050
Sidings to be retired		35,370 "	Cr. 79,805	73,409	Cr. 6,396
			$657,695	$131,959	$ 789,654
Signals			196,780	38,145	234,925
Totals		6,430 L.F.	$854,475	$170,104	$1,024,579

Side track extensions involve the substitution of No. 16 turnouts, 130-lb. rail, for No. 10 turnouts.

Effect of Proposed Track and Signal Plan

(a) The proposed track plan increases the track mileage to the amount of 6,430 linear feet, which will add a maintenance expense of about $2,500 per annum. The proposed signal layout will add a maintenance expense estimated at $9,500 per annum, making a total increased maintenance expense of $12,000 per annum.

(b) It is not anticipated that the proposed improvements will increase the taxes on this line.

(c) Fig. 3 shows a chart of the slow freight train performance, plotting the gross ton miles against the average running time per train for the years 1924 to 1932, inclusive. Lines "AB" and "AC" show 1924 and 1930 performance.

This chart shows an improvement in operations each year from 1924 to 1930. On the basis of 1924 tonnage this improved operation resulted in a reduction in running time per train of 3.2 hours, or approximately 29 per cent, and an increase in capacity of approximately 107 per cent.

The increased improvement in operation between 1924 and 1930 were brought about by intensive studies from time to time of the operations on this division, which resulted in additional second track, relocation and lengthening of sidings, relocation of water stations, increased weight of rail and better maintenance conditions, embracing roadway and track, change in time of trains, heavier power, and larger engine tanks.

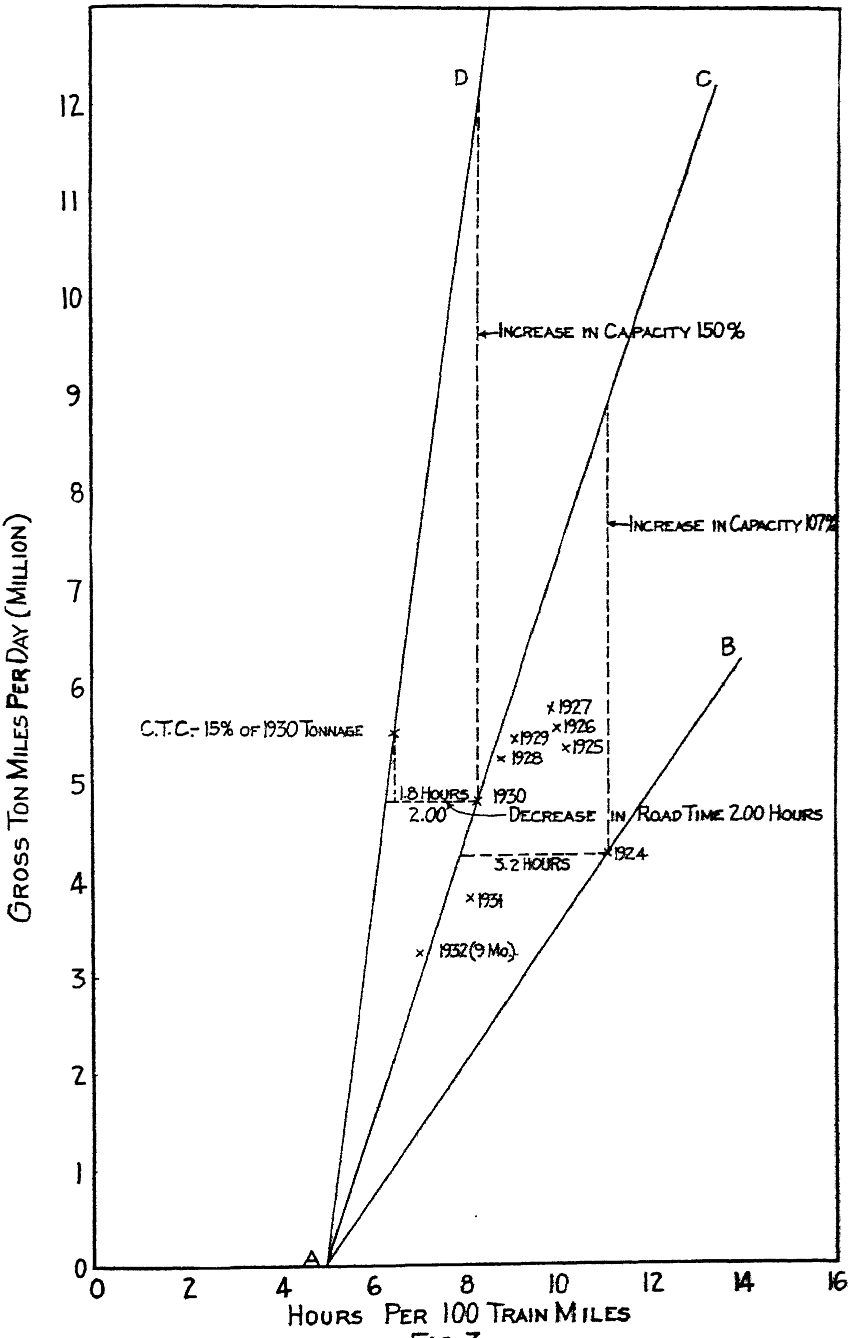
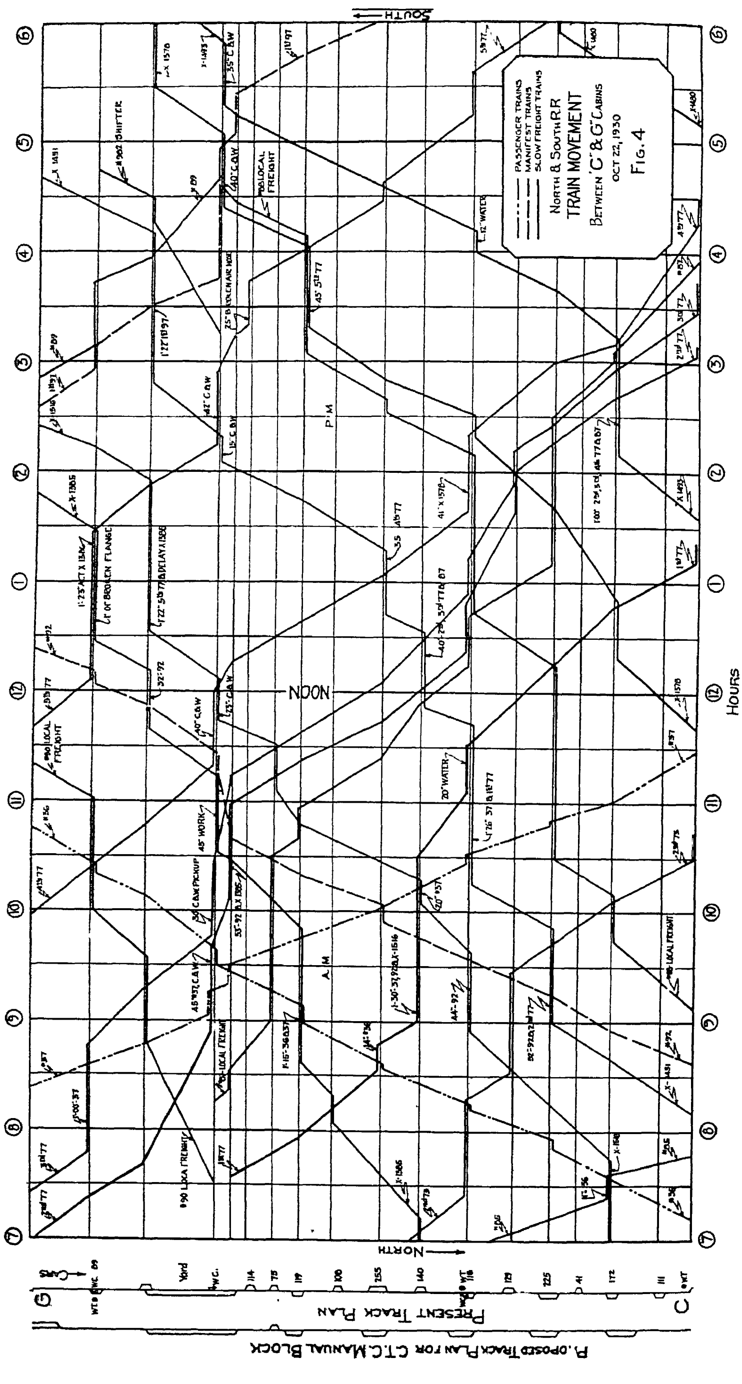

D
C
B
A
12
11
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
GROSS TON MILES PER DAY (MILLION)
INCREASE IN CAPACITY 150%
INCREASE IN CAPACITY 107%
C.T.C.- 15% OF 1930 TONNAGE
1927
1926
1929
1925
1928
1.8 HOURS
1930
2.00
DECREASE IN ROAD TIME 2.00 HOURS
1924
3.2 HOURS
1931
1932 (9 MO.)
HOURS PER 100 TRAIN MILES

FIG. 3


SOUTH
NORTH
NOON
A.M
P.M
HOURS
PASSENGER TRAINS
MANIFEST TRAINS
SLOW FREIGHT TRAINS
NORTH & SOUTH R.R
TRAIN MOVEMENT
BETWEEN 'C' & 'G' CABINS
OCT 22, 1930
FIG. 4
PRESENT TRACK PLAN
PROPOSED TRACK PLAN FOR C.T.C. MANUAL BLOCK

In addition to the actual performance for the years 1924 to 1930, inclusive, the estimated performance for the proposed track plan and C.T.C. signal layout on the basis of 1930 tonnage is shown by the line "AD".

From a study of the train sheets, it is estimated that 1.8 hours per train will be saved, or a reduction of approximately 22 per cent. This was determined by a preliminary study of train movement diagrams, covering typical days in 1930 and 1931. On October 22, 1930, in addition to 4 passenger, 2 local and 4 time freight trains operated on this line, there were 12 slow freight trains. The movements of these trains were plotted on a large time and distance scale diagram, a section of which is reproduced on Fig. 4 for the period between 7 A.M. and 6 P.M. Maintaining the same leaving time at the initial terminals, the trains were then redispatched by assuming the various movements after the installation of the proposed C.T.C. system.

The method of graphic redispatching consists of plotting a record of all trains as they actually ran, on time and distance train charts, and recording the cause of all delays that it is possible to find. After this has been done, each delay is analyzed and the train is advanced by drawing in new lines, if it can be determined definitely or is believed, that, with the additional facilities for receiving information and issuing orders, the train would have advanced to another siding for the meet or pass. In advancing trains on the chart, the same speed is used as was made in the original operation, with the exception that a train is advanced from one to six minutes each time it goes through a switch, depending on the loading of the train.

By reason of the traffic density, as indicated by diagonal lines on Fig. 4, it is impracticable to show the redispatched train movement diagram under the proposed system superimposed over the actual train movement diagram. However, the problem is outlined diagrammatically on Fig. 5, which shows the meeting of 2 trains at passing siding "A". At the lefthand side of this diagram, the present track plan is indicated showing 5 short passing sidings. Adjacent thereto the proposed track plan is indicated, showing 3 short sections of double track. With this rearrangement of the track plan under the

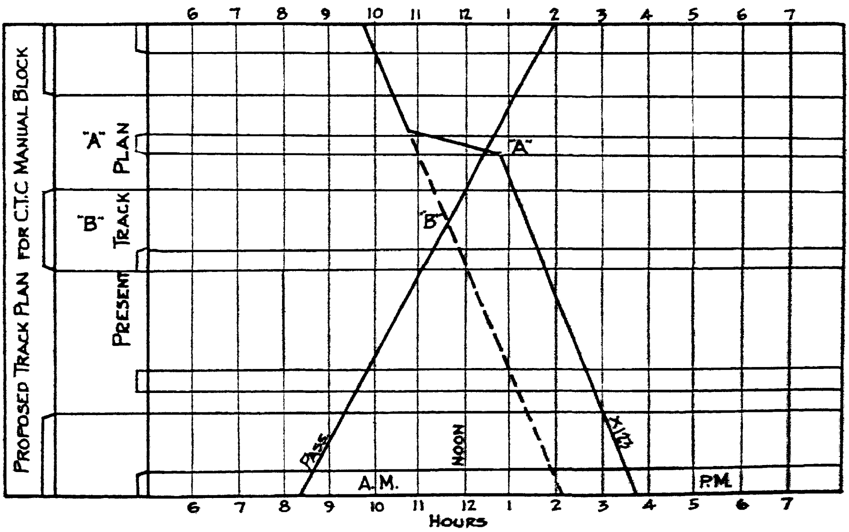


Diagram Showing Method of ReDispatching Trains
Fig. 5

C.T.C. dispatching system, the 2 trains that met at passing siding "A", one of which sustained a delay of about 2 hours, would meet on the short section of double track and pass at "B" without stopping, thereby, in this case, entirely eliminating the delay. This redispatched movement is shown by the dash line.

Each train movement during the 24-hour periods was studied, and the delays were analyzed, keeping in mind that useful delays such as for switching, taking water, etc., would not be changed, except that in taking water prolonged delays which were probably due to interference between trains would be sometimes shortened. The movement of passenger trains as per schedule is generally fixed. The same is generally true as to time freight trains. Therefore, the redispatching study usually only affects the movement of slow freight trains. The result of the study for October 22, 1930, is tabulated in Table 3, from which it will be seen that an average saving of 1 hour 46 minutes per slow freight is forecast.

TABLE NO. 3

SLOW FREIGHT TRAINS ONLY

Train No.	Begin Trip: Place	Begin Trip: Arriving time			Finish Trip: Place	Finish Trip: Arriving Time: Train Orders			Arriving Time: Centralized Control			Elapsed Hours, Train Orders		Time Saved: Train Hours		Time Saved: Overtime Hours		Number of Freight Trains (N)	
												H	M	H	M	H	M		
	SOUTHWARD																		
X1513	E	12	21		F	1	22	A	1	22	A	1	01	0	00	0	00		37
X1385	C	3	45		G	1	48	P	11	13		10	03	2	35			1	00
X1516	C	5	51		G	2	26		11	35		8	35	2	51			1	00
X1451	C	6	31		G	4	40		1	32		10	09	3	08			1	00
X1378	C	11	01		G	8	08		5	30		9	07	2	48			1	00
X1493	C	1	10	P	G	8	18		6	13		7	08	2	05			1	00
X1511	C	9	40		D	11	50		11	34		2	10	0	16				17
					Totals									13	43			5	54
	NORTHWARD																		
2/73	G	2	43	A	C	10	28	A	7	50	A	7	45	2	38			1	00
85	G	5	08		C	7	47		8	02		2	39	-0	15			1	00
1/17	G	7	34		C	1	12	P	11	59		5	38	1	13				70
2/77	G	6	59		C	3	04		1	14	P	8	05	1	50			1	00
3/77	G	7	25		C	3	28		2	27		8	03	1	01			1	00
4/77	G	9	58		C	4	14		4	14		6	16	0	00	0	00	1	00
5/77	G	11	40		C	7	44		6	14		8	04	1	30			1	00
					Totals									7	54			6	70
						Grand Totals								21	37			12	24
						Average								1	46				

NOTE: All time data is between end of double track at "C" and present end of double track at "G".

Tabulation No.

North and South Railroad
Between "C" and "G"
Train Time Data for Trains of 10/22/1930

In order to develop this method with a reasonable degree of accuracy, a study of freight train operation over 10 or 15 consecutive days, or a sufficient period to obtain the performance of 100 or more trains under the most favorable operating conditions is

recommended. The general procedure has been outlined by this Committee and published in the Proceedings, Vol. 32, page 670, under the heading "Log of Freight Train Performance."

On the basis of 1 hour 46 minutes per slow freight train operated over the 85 mile territory, the equivalent saving per mile is 1.2 minutes. This happens to be the average time saved per mile on 10 C.T.C. systems installed in this country.

It is a well-known fact that the train load of heavy tonnage trains is reduced during periods of very heavy traffic or extremely cold weather, in order to facilitate the movement by reducing the delays resulting from stops. Therefore, it is estimated that by the elimination of train stops, etc., it will permit an increase in train load of 15 per cent. The estimated increase in tonnage is supported by the increased tonnage per train from 1924 to 1932, as shown by Table 1. Between 1924 and 1932, the tonnage per train has increased 1,783 tons, or 57 per cent. In 1932, the tonnage increased 858 tons per train, or 21 per cent, over 1930, and in 1932 the tonnage increased 491 tons per train, or 11 per cent, over 1931. As this increased tonnage was the result of eliminating stops, etc., an estimated additional increased tonnage of 15 per cent for the proposed track plan and C.T.C. is reasonable.

The performance line "AD" for the proposed track plan and C.T.C. signal layout was, therefore, plotted for a 15 per cent increased tonnage over 1930 tonnage and a reduction in 1930 running time of 1.8 hours.

The reduction in running time on the basis of 1930 tonnage under the proposed track plan and C.T.C. signal layout would be 2 hours per train, or 24 per cent, and the increase in capacity would be 150 per cent.

A computation of the train miles and train hours that will be saved, based on 1930 operation, is as follows:

TRAINS

Present	= 3,866 trains
Proposed at 15 per cent heavier loading	= 3,866 ÷ 1.15 = 3,362 trains

TRAIN MILES

Present 3,866 trains × 100 miles	= 386,600 train miles
Proposed 3,362 " × 100 "	= 336,200 " "
Total train miles saved	50,400 or approx. 13 per cent

TRAIN HOURS

Present 3,866 trains × 8.3 hours	= 32,088 train hours
Proposed 3,362 " × 6.3 "	= 21,181 " "
Total train hours saved	10,907 or approx. 34 per cent

If no credit is taken for an increased train load, the above computation will be:

Present 3,866 × 8.3 trains	= 32,088 train hours
Proposed 3,866 × 6.3 "	= 24,356 " "
Total train hours saved	7,732 or approx. 24 per cent

(d) The train service cost of operating slow freight trains on this line, under present conditions or under the conditions that existed in previous years, can be estimated to a reasonable degree of accuracy either on per train hour or per train mile basis. To compare with this cost, it is necessary to estimate the cost per train hour or per train mile that will obtain after the proposed facilities have been provided, keeping in mind the necessity to equate the varying unit costs such as wages, fuel, etc. After these costs have been ascertained, they may be applied to the above units, and the annual saving and return on the expenditures may readily be obtained.

Conclusions

Where the distribution of traffic on existing lines results in considerable overtime under timetable, train order, and manual block system, consideration should be given to a rearrangement of tracks by eliminating passing sidings, providing short sections of double track, and installing a system of C.T.C. controlled manual block for directing train movements by signal indication, which will provide:

1. Reduction in overtime by eliminating excessive delays and stops at meeting and passing points, shorter block lengths, reduction in running time, and a reduction in the number of water stops.
2. Increased track capacity.
3. Increased train load.
4. Increased safety in train operation.
5. Increased flexibility of operation by directing train movements by signal indication.
6. Reduction in transportation expense.

Appendix B

(5) METHODS FOR DETERMINING THE MOST ECONOMICAL TRAIN LENGTH CONSIDERING ALL FACTORS ENTERING INTO TRANSPORTATION COSTS

L. S. Rose, Chairman, Sub-Committee; H. C. Crowell, W. W. Houston, G. D. Hughey, E. E. Kimball, J. A. Parant, W. C. Sloan, H. W. Snyder, R. E. VanAtta, John Worley.

On account of the numerous factors which enter into the problem of determining the most economical train length, it seems necessary to begin by classifying as many factors as possible into groups and from a study of the various groups determine what effect each group has on the final results. For any particular case there will be a number of conditions in each group which can be considered more or less fixed and a number of conditions which can be varied. By substituting various values for the variable conditions the effect of these variations can be determined for the different groups and by considering the effect of all the component groups it is theoretically possible to find a set of conditions which will show when the greatest economy has been reached.

The factors having to do with track capacity comprise one group. These have been quite thoroughly discussed in reports recently submitted by this Committee and hence need not be repeated here.

Another group includes those factors which have to do with motive power capacity, another group with capital investments, and a fourth group with operating and maintenance expense. It may be necessary to consider other groups besides those mentioned before a final solution is obtained.

In taking up the motive power group the conditions found are very much involved unless care is taken to correlate conditions so that they can be handled together. The method employed in an attempt at simplification is described in Exhibit A of this Appendix. A summary of the Exhibit and general tables derived therefrom are given later.

Up until about five years ago the characteristics of steam locomotives conformed very closely to Cole's ratios; that is, locomotive proportions generally followed those developed by Cole and adopted by locomotive manufacturers about twenty years ago. During the past five years a number of changes have been made in locomotive designs, particularly as regards the size of firebox, area of grates and design of superheaters which, together with the addition of feed-water heaters and other accessories, have added

greatly to the capacity and efficiency of steam locomotives. Likewise the adoption of large engine tanks has become more or less general even for some of the earlier locomotives which were originally equipped with smaller tanks. As a result there is a difference between the so-called new line and old line of locomotives which is not covered by Cole's formula. For this reason it will be necessary to treat the new line of locomotives as special cases until sufficient data have been collected to revise Cole's formula.

One of the first steps in this study has been to classify various types of steam locomotives according to the percentage of weight on drivers. Some of the details of this investigation are given in the Exhibit. Fig. 1 gives a summary of the data collected as regards familiar types of road locomotives and shows that the weight on drivers for various classes of locomotives varies from 30 per cent to 70 per cent of the total weight of locomotive and tender. The corresponding weight of engine without tender varies from about 58 per cent to 70 per cent of the total weight which means that the tender constitutes between 42 and 30 per cent of the total weight of the locomotive. The latter relation is nearly the correct proportion for tenders of uniform capacity for all locomotives with the same weight per driving axle.

Chart Showing Typical Weight Distribution and Horsepower Capacities Over a Wide Range of Locomotive Designs.

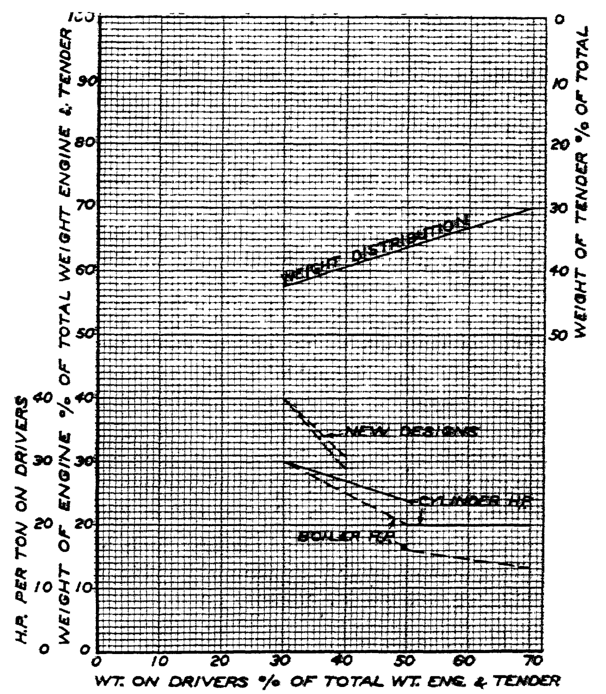


Fig. 1.

This study also brings out the fact that the cylinder horsepower per ton on drivers decreases as the percentage of weight on drivers increases. Likewise the boiler horsepower decreases, but at a more rapid rate than the cylinder horsepower as the percentage

of weight on drivers increases. This is an indication that the boiler is the limiting feature of steam locomotives.

Apparently there is a sharp dividing line between rigid frame and articulated type locomotives due to the fact that a large number of the articulated type locomotives are compound. Some of the older types of rigid frame locomotives such as the consolidation and decapod locomotives also fall in the class with articulated type locomotives.

Some of the more recent designs of locomotives due to various improvements will fall in another class in the range between 30 and 40 per cent weight on drivers as tentatively indicated by dotted lines designated new designs.

Having established a relation between horsepower and percentage weight on drivers, it is a simple matter to compute the maximum tonnage rating as well as the tonnage rating which will produce the maximum gross ton miles per hour on various grades for various classes of locomotives and trains. Thus, if the weight on drivers for a given locomotive is 40 per cent of the total weight including tender, then by referring to the chart in Fig. 1 it will be found that the corresponding boiler horsepower per ton on drivers is 25. By computing the speed tractive effort curves corresponding to 25 horsepower per ton on drivers the speed for any weight train can be obtained by assuming various grades and values of train resistance.

In order to have a ready means of checking the tonnage ratings of various types of locomotives, the following tables covering four classes of locomotives and three classes of trains, namely, Manifest, Coal and Ore trains and Empty trains have been prepared. These tables give the proper tonnage rating to obtain the maximum gross ton miles per hour on various grades, the corresponding speed and the theoretical maximum gross ton miles per hour per ton of locomotive. In addition the maximum trailing tonnage which can be hauled behind the tender is given in columns headed A. These tonnages are based upon a tractive effort equal to 25 per cent of the weight on drivers, assuming that boosters will be able to supply the additional tractive effort necessary to get started. The figures in parentheses following the letter "A" give the speeds at which the maximum tonnage corresponding to any grade can be hauled limited by the boiler capacity of the particular type of locomotive under consideration.

For example, assume a locomotive having 40 per cent of its weight on drivers and that it is desired to find the maximum tonnage rating, also the tonnage rating which will produce the greatest gross ton miles per hour with a coal train on a .3 per cent grade.

By consulting Table 1, page 550, column B of the third group and the line corresponding to .3 per cent grade, the corresponding tonnage is found to be 9.19 or 9.19 times the weight of locomotive including tender. The speed is found to be 29.6 miles per hour and the theoretical maximum gross ton miles per hour 272; that is, 272 times the weight of locomotive and tender. The latter figure is the product of $9.19 \times 29.6 = 272$.

The maximum tonnage rating 19.88 on a .3 per cent grade is found in like manner in Column A which also gives the speed 9.88 in parenthesis. The product of 19.88×9.88 gives 196 gross ton miles per hour which is about 72 per cent of the theoretical maximum gross ton miles per hour. In other words, if the entire road were on a .3 per cent grade against the loaded trains, the maximum gross ton miles would be obtained if the tonnage for this particular class of locomotive were limited to about 46 per cent of its maximum tonnage rating. This ratio varies with the class of power, kind of train and with the grade.

If the road were mostly level, the tonnage rating to produce the theoretical maximum gross ton miles per hour over the level portions is found to be 20.69 times the weight of the locomotive and tender. This is slightly in excess of 19.88, the maximum

TABLE 1

CONDITIONS FOR OBTAINING MAXIMUM GROSS TON MILES PER HOUR FOR VARIOUS CLASSES OF LOCOMOTIVES ON VARIOUS GRADES

MANIFEST TRAINS

Per Cent Grade	Weight on Drivers 30%				Weight on Drivers 35%				Weight on Drivers 40%				Weight on Drivers 45%				Per Cent Grade
	Miles Per Hour	Trailing Tons Per Ton of Loco. A(11.85)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	Miles Per Hour	Trailing Tons Per Ton of Loco. A(10.86)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	Miles Per Hour	Trailing Tons Per Ton of Loco. A(9.88)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	Miles Per Hour	Trailing Tons Per Ton of Loco. A(8.89)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	
-.1	37.3		12.06	450	35.3		14.45	510	32.9		16.87	555	30.2		23.20	701	-.1
0	35.8	26.83	9.64	345	33.9	31.96	11.30	383	31.7	37.24	13.09	415	29.1	42.60	17.70	515	0
.1	34.3	19.30	7.87	270	32.6	22.94	9.29	303	30.6	26.66	10.78	330	28.1	30.42	13.88	390	1
.2	33.0	14.97	6.76	223	31.4	17.80	7.96	250	29.6	20.67	9.19	272	27.3	23.56	11.25	307	.2
.3	31.7	12.17	5.90	187	30.4	14.47	6.91	210	28.7	16.81	8.01	230	26.5	19.16	9.25	245	.3
.4	30.7	10.20	5.21	160	29.4	12.15	6.12	180	27.8	14.12	7.19	195	25.7	16.10	7.86	202	.4
.5	29.7	8.75	4.71	140	28.5	10.43	5.44	155	27.0	12.13	6.30	170	25.0	13.84	7.00	175	.5
.6	28.8	7.63	4.27	123	27.7	9.11	4.98	138	26.3	10.61	5.70	150	24.3	12.11	6.26	152	.6
.7	27.9	6.74	3.94	110	26.9	8.06	4.50	121	25.6	9.40	5.16	132	23.7	10.74	5.74	136	.7
.8	27.1	6.01	3.62	98	26.2	7.21	4.16	109	24.9	8.42	4.70	117	23.2	9.63	5.17	120	.8
.9	26.3	5.41	3.35	88	25.5	6.51	3.80	97	24.3	7.61	4.40	107	22.7	8.72	4.93	112	.9
1.0	25.6	4.91	3.13	80	24.9	5.91	3.57	89	23.7	6.93	4.09	97	22.2	7.94	4.59	102	1.0
1.2	24.3	4.10	2.72	66	23.7	4.97	3.16	75	22.7	5.84	3.66	83	21.2	6.72	4.06	86	1.2
1.4	23.1	3.49	2.42	56	22.7	4.25	2.86	65	21.7	5.02	3.27	71	20.4	5.79	3.68	75	1.4
1.6	22.1	3.01	2.17	48	21.7	3.69	2.53	55	20.9	4.37	2.97	62	19.5	5.05	3.33	65	1.6
1.8	21.1	2.62	1.99	42	20.8	3.24	2.27	48	20.1	3.85	2.74	55	18.8	4.47	3.03	57	1.8
2.0	20.1	2.30	1.79	36	20.0	2.86	2.15	43	19.4	3.42	2.53	49	18.2	3.98	2.75	50	2.0
2.2	19.3	2.04	1.66	32	19.2	2.55	1.98	38	18.7	3.06	2.35	44	17.6	3.58	2.61	46	2.2
2.4	18.5	1.81	1.51	28	18.4	2.28	1.85	34	18.1	2.76	2.21	40	17.0	3.23	2.41	41	2.4

TABLE 1—(Continued)

COAL AND ORE TRAINS

Per Cent Grade	Weight on Drivers 30%				Weight on Drivers 35%				Weight on Drivers 40%				Weight on Drivers 45%				Per Cent Grade
	Miles Per Hour	Trailing Tons Per Ton of Loco. A(11.65)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	Miles Per Hour	Trailing Tons Per Ton of Loco. A(10.86)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	Miles Per Hour	Trailing Tons Per Ton of Loco. A(9.88)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	Miles Per Hour	Trailing Tons Per Ton of Loco. A(8.89)	Trailing Tons Per Ton of Loco. B	G.T.M. Per Hr. Per Ton of Loco.	
-.1	39.6		17.68	700	37.2		21.77	810	---	---	---	---	---	---	---	---	-.1
.0	37.7	39.43	12.87	485	35.5	46.95	15.07	535	33.1	54.87	20.69	685	30.2	62.92	23.18	700	.0
.1	36.0	25.27	9.86	355	34.0	29.97	11.53	392	31.8	34.84	13.21	420	29.1	39.77	17.77	517	.1
.2	34.5	18.46	8.12	280	32.7	21.88	9.48	310	30.7	25.39	11.08	340	28.1	28.92	13.88	390	.2
.3	33.2	14.45	6.93	230	31.5	17.13	8.10	255	29.6	19.88	9.19	272	27.2	22.64	11.03	300	.3
.4	31.9	11.81	6.02	192	30.5	14.02	7.05	215	28.6	16.27	7.87	225	26.4	18.53	9.09	240	.4
.5	30.8	9.94	5.29	163	29.5	11.82	6.17	182	27.7	13.73	6.86	190	25.7	15.64	7.86	202	.5
.6	29.8	8.55	4.73	141	28.6	10.15	5.52	158	26.9	11.84	6.21	167	25.0	13.50	7.00	175	.6
.7	28.9	7.47	4.33	125	27.8	8.92	5.00	139	26.2	10.38	5.65	148	24.4	11.84	6.39	156	.7
.8	28.0	6.61	3.96	111	27.0	7.91	4.56	123	25.6	9.21	5.16	132	23.8	10.53	5.84	139	.8
.9	27.1	5.91	3.62	98	26.3	7.08	4.18	110	25.0	8.27	4.80	120	23.2	9.46	5.30	123	.9
1.0	26.3	5.33	3.35	88	25.6	6.40	3.89	99	24.4	7.48	4.43	108	22.6	8.57	4.87	110	1.0
1.2	24.9	4.41	2.89	72	24.3	5.33	3.33	81	23.2	6.25	3.88	90	21.6	7.18	4.26	92	1.2
1.4	23.7	3.73	2.53	60	23.2	4.53	2.97	69	22.1	5.33	3.39	75	20.7	6.14	3.77	78	1.4
1.6	22.6	3.20	2.30	52	22.1	3.91	2.62	58	21.3	4.62	3.14	67	19.9	5.33	3.47	69	1.6
1.8	21.5	2.78	2.09	45	21.2	3.41	2.41	51	20.4	4.05	2.84	58	19.2	4.69	3.18	61	1.8
2.0	20.5	2.43	1.90	39	20.3	3.01	2.22	45	19.6	3.59	2.55	50	18.5	4.17	2.92	54	2.0
2.2	19.6	2.14	1.73	34	19.5	2.67	2.05	40	18.9	3.20	2.38	45	17.9	3.94	2.74	49	2.2
2.4	18.8	1.90	1.60	30	18.7	2.39	1.87	36	18.2	2.88	2.20	40	17.3	3.37	2.49	43	2.4

TABLE 1—(Continued)

EMPTY TRAINS

Per Cent Grade	Weight on Drivers 30% — Miles Per Hour	30% — Trailing Tons Per Ton of Loco. A(11.85)	30% — Trailing Tons Per Ton of Loco. B	30% — G.T.M. Per Hr. Per Ton of Loco.	Weight on Drivers 35% — Miles Per Hour	35% — Trailing Tons Per Ton of Loco. A(10.86)	35% — Trailing Tons Per Ton of Loco. B	35% — G.T.M. Per Hr. Per Ton of Loco.	Weight on Drivers 40% — Miles Per Hour	40% — Trailing Tons Per Ton of Loco. A(9.88)	40% — Trailing Tons Per Ton of Loco. B	40% — G.T.M. Per Hr. Per Ton of Loco.	Weight on Drivers 45% — Miles Per Hour	45% — Trailing Tons Per Ton of Loco. A(8.89)	45% — Trailing Tons Per Ton of Loco. B	45% — G.T.M. Per Hr. Per Ton of Loco.	Per Cent Grade
-.4	38.1		13.71	522	36.4		17.99	655	---	-	---	---	---	---	---	---	-.4
-.3	36.6		10.79	395	34.8		13.22	460	32.7		16.06	525	30.0		22.00	660	-.3
-.2	35.1		8.75	307	33.3		10.36	345	31.4		12.58	395	29.0		17.24	500	-.2
-.1	33.9		7.53	255	32.2		8.85	285	30.3		10.23	310	28.0		13.39	375	-.1
0	32.7	16.10	6.58	215	31.1	19.21	7.65	238	29.4	22.39	8.84	260	27.2	25.60	10.85	295	0
.1	31.5	12.93	5.75	181	30.2	15.42	6.72	203	28.5	17.96	7.79	222	26.4	20.61	8.98	237	.1
.2	30.5	10.75	5.15	157	29.3	12.82	6.01	176	27.7	14.94	6.93	192	25.7	17.06	7.86	202	.2
.3	29.5	9.16	4.61	136	28.5	10.94	5.44	155	26.9	12.75	6.13	165	25.0	14.56	6.96	174	.3
.4	28.6	7.94	4.23	121	27.7	9.50	4.95	137	26.2	11.08	5.65	148	24.4	12.67	6.35	155	.4
.5	27.8	6.99	3.89	108	26.9	8.38	4.50	121	25.5	9.78	5.10	130	23.8	11.16	5.84	139	.5
.6	27.0	6.22	3.59	97	26.2	7.47	4.16	109	24.9	8.73	4.70	117	23.2	10.00	5.34	124	.6
.7	26.3	5.59	3.35	88	25.5	6.72	3.80	97	24.3	7.87	4.40	107	22.7	9.02	4.93	112	.7
.8	25.6	5.06	3.13	80	24.9	6.10	3.57	89	23.7	7.15	4.09	97	22.2	8.20	4.59	102	.8
.9	24.9	4.60	2.89	72	24.3	5.56	3.33	81	23.2	6.53	3.88	90	21.7	7.50	4.29	93	.9
1.0	24.3	4.21	2.72	66	23.8	5.11	3.15	75	22.7	6.01	3.66	83	21.2	6.91	4.01	85	1.0
1.2	23.2	3.58	2.46	57	22.7	4.36	2.86	65	21.8	5.14	3.30	72	20.4	5.93	3.68	75	1.2
1.4	22.1	3.08	2.17	48	21.8	3.77	2.57	56	20.9	4.47	2.97	62	19.6	5.17	3.32	65	1.4
1.6	21.1	2.68	1.99	42	20.9	3.30	2.34	49	20.1	3.93	2.74	55	18.9	4.56	3.07	58	1.6
1.8	20.2	2.35	1.83	37	20.0	2.92	2.15	43	19.4	3.49	2.53	49	18.3	4.06	2.79	51	1.8
2.0	19.3	2.08	1.66	32	19.2	2.60	1.98	38	18.7	3.12	2.35	44	17.7	3.64	2.60	46	2.0
2.2	18.5	1.84	1.51	28	18.4	2.32	1.79	33	18.0	2.81	2.17	39	17.1	3.29	2.46	42	2.2
2.4	17.7	1.64	1.41	25	17.8	2.09	1.69	30	17.4	2.54	2.01	35	16.6	2.99	2.30	38	2.4

Trailing Tons "A" give the maximum trailing tons per ton of locomotive weight based upon a tractive effort equal to 25% of the weight on drivers. The product of this tonnage times the miles per hour shown in parentheses at the head of the column gives the gross ton miles obtainable under maximum tonnage conditions. Compare gross ton miles thus obtained with values shown in table.

Trailing Tons "B" give the tonnage ratings necessary to obtain the maximum gross ton miles per hour per ton of locomotive weight and corresponds to the miles per hour and gross ton miles given in the table.

tonnage rating on a .3 per cent grade for locomotives having 40 per cent or more of their weight on drivers. On such a road assuming no "fill outs", the limiting tonnage on .3 per cent grade would be controlling and would produce very nearly the maximum gross ton miles per hour on level track. Theoretically the gross ton miles per hour would be 196 on .3 per cent grade and between (19.88 $\times$ 33.1) = 658 and 685 on level track. The mean value 672 divided by 19.88 will give the corresponding speed, 33.8 m.p.h.

If the maximum grade were .2 per cent instead of .3 per cent, the maximum tonnage rating 25.39 on .2 per cent grade produces 25.39 $\times$ 9.88 or 251 gross ton miles per hour and on level track it produces between (54.87 $\times$ 9.88) = 542 and 685 gross ton miles per hour. In order to find the corresponding speed it is necessary to interpolate between 542 and 685 because the speed will be between 9.88 and 33.1 since 25.39 is greater than 20.69, the weight on level track corresponding to 33.1 miles per hour.

By interpolation the difference between 20.69 and 25.39 divided by the difference between 54.87 and 20.69 and multiplied by the difference between 685 and 542 gives $\frac{4.70}{34.18} \times 143 = 20$. Subtracting 20 from 685 gives 665 gross ton miles per hour on level track. The corresponding speed can be found by dividing 665 by 25.39 equals 26.2.

The following example is given to illustrate the application of these tables to a simple case.

Given a road 100 miles long composed of 25 miles of .2 per cent up-grade, 50 miles of level track and 25 miles of .3 per cent down-grade over which it is proposed to haul coal in one direction and empty cars in the opposite direction; find the time and gross ton miles per hour for round trip excluding all delays, assuming a locomotive having 40 per cent of its weight on drivers.

Using the results derived above, the maximum tonnage rating for a coal train on .2 per cent grade is 25.39 tons per ton of locomotive, including tender. The corresponding speed is 9.88 miles per hour. The speed of a coal train weighing 25.39 times the weight of the locomotive on level track has been found above to be 26.2 miles per hour. The speed on .3 per cent down-grade will depend upon the speed limits imposed, assume 35 miles per hour.

Thus the time required to make the run of 100 miles with loaded train exclusive of stops or slow-downs is 25/9.88 plus 50/26.2 plus 25/35 or 5.14 hours, which is equivalent to an average speed of 19.5 miles per hour over the entire line. The product 25.39 $\times$ 19.5 gives an average of 494 gross ton miles per hour.

It can be assumed that the empty train in the opposite direction will weigh one-fourth as much as the loaded train or 6.35 times the weight of the locomotive and tender. From inspection of the table under empty trains, it will be seen that the weight of the empty train is between the weights given in columns A and B for .3 per cent grade. The speed corresponding to a train weight of 6.34 times the weight of locomotive and tender can be obtained by interpolation as explained above; that is,

$$\frac{6.34 - 6.13}{12.75 - 6.13} \times (165 - 9.88 \times 12.75) = 1.2$$

Subtracting 1.2 from the maximum gross ton miles per hour, 165 — 1.2 = 164 approximately. Dividing 164 by 6.34 gives 25.9 miles per hour for the speed on the .3 per cent up-grade.

The speed on level track for an empty train weighing 6.34 times the weight of the locomotive can be found by noting that the speed for a train weighing 8.84 times the weight of the locomotive is 29.4 miles per hour and the maximum gross ton miles per

hour is 260. The gross ton miles per hour for a train weighing 6.34 times the weight of locomotive must be less than 260 and more than $(6.34 \times 29.4) = 186$. Taking the average value for gross ton miles per hour 223, and dividing by 6.34 gives 35+ miles per hour which is slightly above the speed limit assumed.*

The speed on the .2 per cent down-grade will likewise be above the speed limit, hence 35 miles per hour will be taken for the speed over the down-grade section. Hence the running time excluding all stops and delays will be 25/25.9 plus 50/35 plus 25/35 equals 3.11 hours and the average speed 100/3.11 equals 32.2 miles per hour. The gross ton miles per hour for the return trip with empty train amounts to 6.34×32.2 equals 204. The average gross ton miles per train hour for the round trip therefore amounts to 347 times the weight of locomotive and tender.

If the proposed locomotive and tender weigh 470 tons, then the gross ton miles per hour for the round trip considering only the possibilities of the motive power will equal 347×470 or 163,000 exclusive of locomotive and tender. The gross ton miles per hour obtained in practice will be much less than derived in this manner because of the effect of track capacity and delays inherent in the methods of operation. When applied to various classes of steam locomotives, the results will be comparative so far as the motive power alone is concerned.

As a matter of general information, the following table gives the average gross ton miles per hour exclusive of locomotive and tender obtained from reports published by the Interstate Commerce Commission for the past eleven years.

TABLE 2

GROSS TON MILES PER HOUR PER TON OF LOCOMOTIVE FOR RAILWAYS IN THE UNITED STATES 1921–1931

Year	*Trailing Tons*	*G.T.M. Per Hr.*	*Year*	*Trailing Tons*	*G.T.M. Per Hr.*
1921	7.00	90.6	1927	7.48	104.0
1922	7.06	87.8	1928	7.56	110.1
1923	7.22	89.0	1929	7.50	111.6
1924	7.24	93.2	1930	7.38	114.5
1925	7.40	97.6	1931	8.00	114.8
1926	7.45	100.2	1932		

In order to obtain a mathematical solution of the problem for finding the maximum gross ton miles per hour it has been necessary to derive an empirical equation which will closely approximate Cole's ratios or the actual characteristics of steam locomotives. Such an equation has been used to determine the speed which will give the theoretical maximum gross ton miles per hour on any grade or for any class of train or locomotive. Given the speed the corresponding tonnage can be obtained.

The equation developed for this purpose is based on locomotives equipped with a booster or engine equipped tender to supply the higher tractive efforts at low speed. In some types of locomotives the theoretical maximum gross ton miles per hour obtained mathematically require the use of the booster continuously, but in practice such conditions do not arise because other types of locomotives better suited for the service are employed.

In general, there are about four classes of trains; namely, passenger trains, manifest freight trains, coal or ore trains and empty freight trains. In the case of passenger

* When the tonnage hauled is less than that shown in Column B for the conditions involved, it is necessary to compute the corresponding gross ton miles per hour from which the corresponding speed can be obtained. The corresponding gross ton miles per hour is approximately the mean between the maximum gross ton miles per hour corresponding to the tonnage given in Column B and the product of the tonnage hauled times the speed corresponding to the maximum gross ton miles per hour. The speed can be obtained by dividing the mean gross ton miles per hour by the tonnage hauled.

trains the most economical train length does not enter into the problem because the question of speed is more important. To some extent speed is important in some classes of manifest freight, particularly where the trains are made up of refrigerator cars. It has been assumed that the problem chiefly applies to typical manifest trains made up of all types of cars loaded with miscellaneous products and averaging about 40 tons per car. The problem also applies to typical coal and ore trains made up of cars weighing about 80 tons per car loaded, and in some cases to empty cars weighing about 20 tons per car light.

In other words, the tables showing the tonnage rating and corresponding speed to obtain the maximum gross ton miles per hour per ton of locomotive weight have been computed on the basis of three different values of train resistance; namely, on the basis of four-axle freight cars weighing 40 tons per car for manifest trains, four-axle freight cars weighing 80 tons per car for coal and ore trains and four-axle freight cars weighing 20 tons per car for empty trains. All of these tables are based upon old line locomotives without the recent improvements in firebox design and other elements which go with the new type of construction. The trend in the construction of new locomotives is discussed in the Exhibit so that tables for special purposes can be worked out as may be required.

The discussion also brings out other relations in regard to rated horsepower capacity per ton, boiler capacity, weight on drivers and tender weights which have been used in the compilation of the tables submitted with this report. In individual cases for which the tables may be used the conditions may not be the same as those assumed; in such cases adjustments may have to be made or new values computed as described in the Exhibit.

For example, if the boiler horsepower for a particular locomotive having 40 per cent of its weight on drivers is 20 h.p. instead of 25 h.p. per ton on drivers as called for by Fig. 1, then the speeds and gross ton miles per train hour should be reduced in the ratio of 20 to 25.

Action Recommended

The Committee recommends that this report be received as information.

Exhibit A

LOCOMOTIVE DEVELOPMENT

The purpose of this exhibit is to present a few notes in regard to the fundamental principles of Locomotive Traction in order to show how a number of factors pertaining to the motive power can be correlated so as to simplify the solution of some of the operating problems which depend on them. The results obtained from the discussion which follows have been summarized in table form as shown in Appendix "B" covering three typical classes of trains, and several classes of locomotives. Other useful tables will be found in this exhibit to show how the final results have been derived.

Fundamental Principles

In general, the pulling power of all types of locomotives is limited in two ways, one by the amount of adhesion existing between the driving wheels and the rails and the other by the amount of power which can be supplied to the driving wheels. Unfortunately, in regard to the first limitation the adhesion between the driving wheels and the rails is not constant, but depends upon the weight on drivers and the condition of the rails. Under poor rail conditions, the adhesion may be less than 5 per cent of the weight on drivers, whereas under exceptionally good conditions of dry rail well sanded, the friction may amount to more than 40 per cent of the weight on drivers. In other words, under natural conditions, the friction which prevents the drivers from slipping may vary over a wide range, but ordinarily it amounts to about 25 per cent of the weight on drivers and this value which corresponds to an adhesion factor of 4 can almost always be obtained by the use of sand. It is therefore generally assumed that the maximum pulling power of a locomotive limited by adhesion can be taken at 25 per cent of the weight on drivers for starting trains from rest.

Assuming that the adhesion between the drivers and the rail is constant at all speeds then the horsepower which can be utilized at various speeds of the locomotive without slipping the drivers will be proportional to the speed and can be represented graphically by the line *OA* Fig. 2 which is one boundary.

The amount of power which can be supplied to the drivers and which is the second fundamental consideration involved, depends upon the type of locomotive and the limitations placed on its physical dimensions, weights, etc. It will be found in the case of steam locomotives that the limiting feature is generally the capacity of the boiler to produce steam. This capacity to produce steam is a measure of the horsepower which is theoretically available for moving the locomotive and train and can be represented by a horizontal line *BC* Fig. 2 which forms another boundary. If this is the largest boiler which can be furnished without exceeding the specified weight on drivers then the horsepower limits of the locomotive will come within the horizontal axis and these boundaries.

The power represented by the capacity of the boiler is converted into mechanical power in the cylinders of the locomotive. The power which they can develop depends upon how much steam can pass through their ports and this depends on how long the ports or valves remain open. At low speeds the ports remain open for the full travel of the pistons, whereas at high speed they are closed before the pistons reach the ends of their strokes and the steam confined is allowed to expand before it is exhausted into the smoke box. Under these conditions the horsepower obtained from a given amount of steam is greater than when the steam is not allowed to expand. For this reason the horsepower developed in the cylinders depends upon the speed of the locomotive as shown by the curve *DE*.

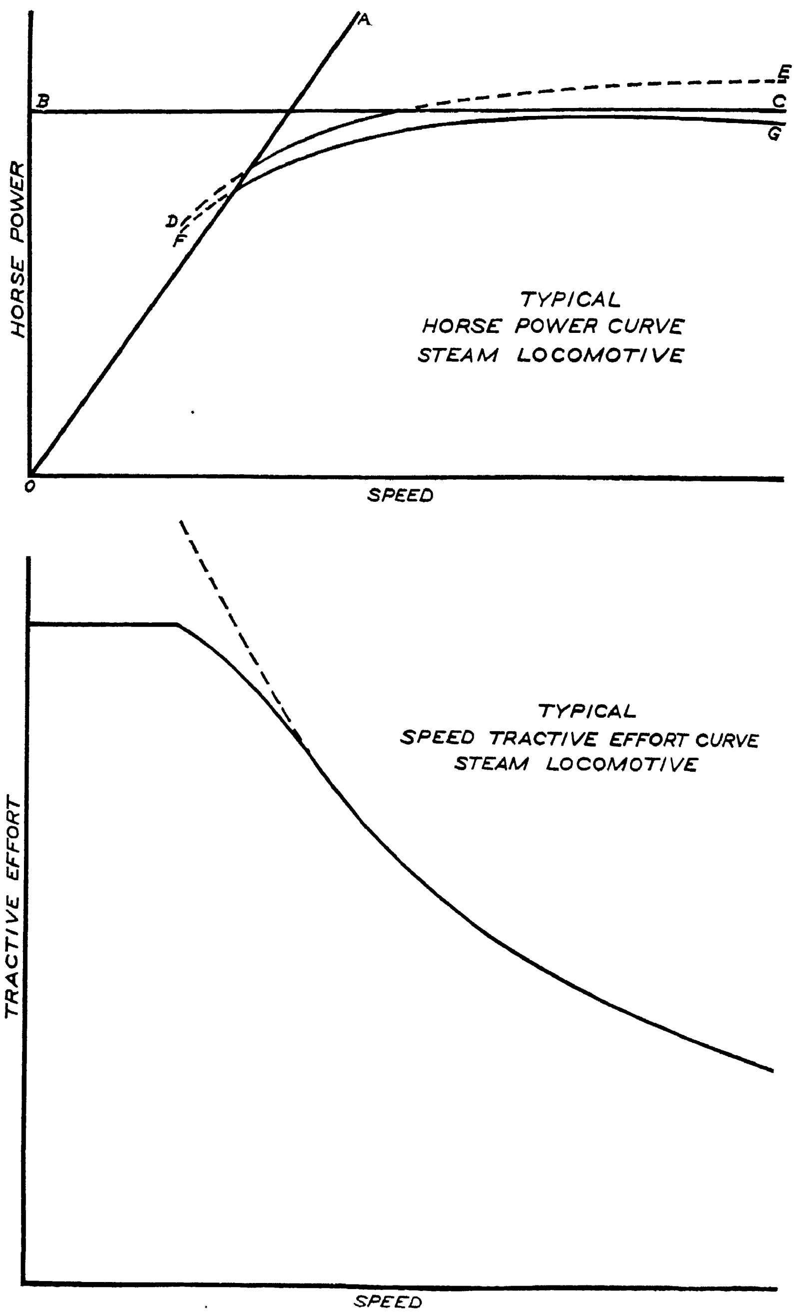

A
E
B
C
G
D
F
HORSE POWER
TYPICAL
HORSE POWER CURVE
STEAM LOCOMOTIVE
O
SPEED
TYPICAL
SPEED TRACTIVE EFFORT CURVE
STEAM LOCOMOTIVE
TRACTIVE EFFORT
SPEED

FIG. 2.

The cylinders assumed are theoretically more than large enough to slip the drivers as indicated by the fact that the dotted portion of the line DE crosses the line OA. Similarly, the cylinders are capable of economically using more steam than the boiler can produce under normal conditions as indicated by the fact that the line DE crosses the line BC.

Theoretically the cylinders can be made any size. If they are made too small they will not be able to furnish enough power to utilize all of the tractive effort available with the given weight on drivers or all of the steam the boiler is capable of producing. This would be an uneconomical design seldom found in practice because designing engineers begin by estimating the weight on drivers and then proportion the cylinders for power enough to slip the drivers and then design the running gear for a boiler and fire box capable of producing a sufficient amount of steam to supply the cylinders. If this cannot be done without exceeding the estimated weight on drivers or clearance limits then it is necessary to make various compromises as required; generally resulting in reduced boiler capacity. For the present let it be assumed that 100 per cent boiler capacity can be obtained, resulting in a perfectly proportioned locomotive.

Effect of Power Losses on Tractive Effort

All the power developed in the cylinders is not actually transmitted to the driving axles because part of it is used in overcoming the friction of mechanical parts, hence it is necessary to represent the horsepower delivered to the driving axles, (usually referred to as driver horsepower) by the line FG, Fig. 2 in order to show the horsepower available for doing useful work. The method used in obtaining cylinder and tractive effort horsepower will be explained later.

The force or tractive effort applied to the driving axles at various speeds can be obtained from the curve FG by substituting in the formula:

$$LBS \text{ (Tractive Effort)} = \frac{375 \times \text{HP}}{\text{MPH}}$$

The tractive efforts thus obtained are the forces available for overcoming locomotive and train resistance and are plotted in lower half of Fig. 2.

Train Resistance

The force or friction opposing the movement of a train is known as train resistance. Values of this resistance expressed in pounds per ton have been determined experimentally over a wide range of conditions by a number of authorities. Recently, W. J. Davis, Jr., by correlating the work of these different authorities has been able to derive a number of empirical formulas which he has published for calculating the tractive resistance of various types of locomotives and cars. A summary of these formulas, applicable to level tangent track is given in Table 3 on the following page.

In order to show the difference in train resistance between manifest, coal and ore trains and empty trains, the resistance of 4-axle freight cars weighing 40, 80 and 20 tons, respectively, are tabulated in Table 4, page 559. The resistance of passenger trains computed in like manner by corresponding formulas will be found to approximate the values shown for heavy freight cars. In this discussion the locomotive resistance in pounds per ton has been assumed the same as for the train, the basis for which will be explained later. If desired the resistance of the locomotive can be calculated by substituting appropriate factors in the locomotive formula.

TABLE 3

TRAIN RESISTANCE FORMULAS

W. J. Davis, Jr.

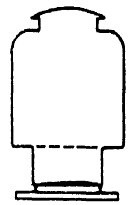
LOCOMOTIVE AND MOTOR CAR SERVICE

SYMBOLS

R = Tractive resistance in pounds per ton (2000 lb.) on tangent level track.
A = Area in square feet of cross-section of locomotive or car body and trucks.
V = Speed in miles per hour.
n = Number of axles per car.
w = Average weight per axle in tons.
wn = Average weight of locomotive or car.

VALUES OF A

Locomotives: 50 tons........	105 sq. ft.
" 70 tons........	110 "
" 100 tons and over	120 "
Freight cars................	85-90 "
Passenger cars.............	120 "
Multiple-unit cars..........	100-110 "
Motor cars: 2 trucks.......	80-100 "
" " 1 truck........	70- 75 "



WHERE USED	USUAL FORMULAS Recommended for convenience in calculation. Approved for axle weights in excess of 5 tons.	GENERAL FORMULAS Applicable to all axle weights. To be used when axle weights are less than 5 tons
Locomotives...........	$R=1.3+\frac{29}{w}+0.03\ V+\frac{0.0024\ A\ V^2}{wn}$	$R=\frac{9.4}{\sqrt{w}}+\frac{12.5}{w}+0.03\ V+\frac{0.0024\ A\ V^2}{wn}$
Freight Cars...........	$R=1.3+\frac{29}{w}+0.045\ V+\frac{0.0005\ A\ V^2}{wn}$	$R=\frac{9.4}{\sqrt{w}}+\frac{12.5}{w}+0.045\ V+\frac{0.0005\ A\ V^2}{wn}$
Passenger Cars (Vestibuled)	$R=1.3+\frac{29}{w}+0.03\ V+\frac{0.00034\ A\ V^2}{wn}$	$R=\frac{9.4}{\sqrt{w}}+\frac{12.5}{w}+0.03\ V+\frac{0.00034\ A\ V^2}{wn}$
Multiple-unit Trains — Leading Car. (Vestibuled)	$R=1.3+\frac{29}{w}+0.045\ V+\frac{0.0024\ A\ V^2}{wn}$	$R=\frac{9.4}{\sqrt{w}}+\frac{12.5}{w}+0.045\ V+\frac{0.0024\ A\ V^2}{wn}$
Multiple-unit Trains — Trailing Cars.	$R=1.3+\frac{29}{w}+0.045\ V+\frac{0.00034\ A\ V^2}{wn}$	$R=\frac{9.4}{\sqrt{w}}+\frac{12.5}{w}+0.045\ V+\frac{0.00034\ A\ V^2}{wn}$
Motor Cars............	$R=1.3+\frac{29}{w}+0.09\ V+\frac{0.0024\ A\ V^2}{wn}$	$R=\frac{9.4}{\sqrt{w}}+\frac{12.5}{w}+0.09\ V+\frac{0.0024\ A\ V^2}{wn}$

EXPLANATORY NOTE

The first two terms of the equations represent journal friction almost entirely. They have been derived from dynamometer and coasting tests on standard freight and passenger cars and electric locomotives and are based on oil lubrication with average temperature conditions. Journal friction may be increased 20 to 40 per cent at temperatures below freezing.

The third term comprises resistances due to flange friction, concussion, swaying, and miscellaneous frictions proportional to the speed. The factor for this element is decreased by increase in length of truck wheel base and increased by poor road bed conditions and inferior riding qualities of motor cars.

The last term gives air resistance for average weight of car or locomotive in pounds per ton for standard types of equipment. No allowance is made for head winds or strong side winds.

Locomotive resistance represents tractive effort delivered to driving axles and does not include friction losses in gears, motor bearings or other parts of the driving equipment, as these are usually covered in the motive power efficiency.

The formulas are based on tests taken under mild weather conditions. Values obtained from them may be used as found in calculations relating to electric distributing systems, substations, energy consumption, and power demand. In the determination of electric motor characteristics and gear reductions to meet particular speed requirements, however, it may be desirable to add a small percentage to the required speed as a protection against unusual conditions.

TABLE 4

FREIGHT TRAIN RESISTANCE

BASED ON FORMULA $R = 1.3 + \frac{29}{W} + .045\,V + \frac{.0005\,AV^2}{Wn}$

$= a + b + c + d$

TYPICAL MANIFEST TRAINS
40-TON FREIGHT CARS WITH 4-WHEEL TRUCKS

FOR-MULA	MILES PER HOUR									
	10	15	20	25	30	35	40	45	50	60
a	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
b	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
c	.45	.68	.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70
d	.11	.25	.44	.69	.99	1.35	1.76	2.23	2.75	3.96
Total	4.76	5.13	5.54	6.02	6.54	7.13	7.76	8.46	9.20	10.86
e	.48	.51	.55	.60	.65	.71	.78	.85	.92	1.09
Total	5.24	5.64	6.09	6.62	7.19	7.84	8.54	9.31	10.12	11.95

TYPICAL COAL AND ORE TRAINS
80-TON FREIGHT CARS WITH 4-WHEEL TRUCKS

FOR-MULA	MILES PER HOUR									
	10	15	20	25	30	35	40	45	50	60
a	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
b	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
c	.45	.68	.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70
d	.06	.13	.23	.35	.51	.72	.90	1.14	1.41	2.03
Total	3.26	3.56	3.88	4.23	4.61	5.05	5.45	5.92	6.41	7.48
e	.33	.36	.39	.42	.46	.51	.55	.59	.64	.75
Total	3.59	3.92	4.27	4.65	5.07	5.56	6.00	6.51	7.05	8.23

TYPICAL EMPTY TRAIN
20-TON FREIGHT CARS WITH 4-WHEEL TRUCKS

FOR-MULA	MILES PER HOUR									
	10	15	20	25	30	35	40	45	50	60
a	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
b	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.80
c	.45	.68	.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70
d	.23	.51	.90	1.41	2.03	2.76	3.60	4.56	5.63	8.10
Total	7.78	8.29	8.90	9.64	10.48	11.44	12.50	13.69	14.98	17.90
e	.78	.83	.89	.96	1.05	1.14	1.25	1.37	1.50	1.79
Total	8.56	9.12	9.79	10.60	11.53	12.58	13.75	15.06	16.48	19.69

e = Adjustment for Normal Weather Conditions, Inferior Track, etc.

Curve and Grade Resistance

It is necessary to adjust the values obtained by these formulas to correct for curve and grade resistance. The adjustment added for curvature is generally taken at .8-lb. per ton per degree of curve but when curves occur on grades it is usually customary in location to lower the grade an amount sufficient to compensate for the added resistance of the curve; hence in these cases no adjustment should be added. However, when grades are determined from the differences in elevation then for traction purposes it is necessary to add .8-lb. per ton per degree of curve for curve resistance.

The *work* done in rounding a curve is proportional to the degrees of central angle and theoretically is independent of the degree of curve; thus in some cases it is customary to adjust for average curvature by adding .8-lb. per degree of central angle included in the section or district under consideration, or to consider the average grade as the difference in elevation plus .04-ft. per degree of central angle for ascending grades and minus .04-ft. per degree for descending grades.

The adjustment for grade resistance amounts to 20-lb. per ton (2000-lb.) and is additive for trains moving against the grade and subtractive when moving with the grade.

Tonnage Rating of Locomotives

The tonnage rating of a locomotive is understood to mean the tonnage which it is capable of hauling over the ruling grade found on the profile at a given speed. It is obtained by dividing the tractive effort available at the rim of the driving wheel of the locomotive by the train resistance per ton and subtracting the weight of the locomotive and tender which gives the trailing weight in tons.

A tractive effort of 400 pounds is sufficient to haul 80 tons on level tangent track assuming 5 pounds per ton for train resistance. If the entire locomotive weight is on drivers and equal to one ton then the trailing weight on level tangent track will amount to (80 — 1) or 79 tons or 79 times the weight of the locomotive.

If only half of the locomotive weight is on drivers the locomotive will weigh two tons for every 400 pounds tractive effort, hence the trailing weight which it is capable of hauling will be 80 — 2 or 78 tons, which is 39 times the weight of the total locomotive. Likewise, if only 30 per cent of the locomotive weight is on drivers, the total locomotive will weigh $3\frac{1}{3}$ tons for every 400 pounds tractive effort, and the trailing weight which it is capable of hauling will be 80 — $3\frac{1}{3}$ or $76\frac{2}{3}$ tons, which equals $.3 \times 76\frac{2}{3}$ or 23 times the total weight of locomotive.

On a one per cent grade, the tonnage which 400 pounds tractive effort will haul is reduced from 80 to 16 tons and the trailing weights for locomotives having 50 and 30 per cent of their weight on drivers are correspondingly reduced from 39 and 23 to 7 and 3.8 times the weight of locomotive. Other values of trailing tonnage in terms of total weight of locomotive will be found in Table 5, following, for various grades and weights on drivers.

It will be seen from this table for example that on a 1.6 per cent grade, one locomotive having 50 per cent of its weight on drivers is equivalent in hauling capacity to two locomotives of the same weight having only 30 per cent of their weight on drivers and likewise a locomotive having 70 per cent of its weight on drivers is equivalent in hauling capacity to three locomotives of the same weight having only 30 per cent of their weight on drivers.

The desirability of weight on drivers for locomotives in heavy grade service is thus evident.

TABLE 5

THEORETICAL MAXIMUM TRAILING TONS WHICH CAN BE HAULED PER TON TOTAL WEIGHT OF LOCOMOTIVE

(Including Tender) on Various Grades

Based on 20 Per cent Coefficient of Adhesion and
5 Lb. per Ton Train Resistance

PERCENT GRADE	PERCENTAGE OF TOTAL LOCO. WT. ON DRIVERS					
	30	40	50	70	90	100
-0.2	119.0	159.0	199.0	279.0	359.0	399.0
-0.1	39.0	52.3	65.7	92.3	119.0	132.3
0.0	23.0	31.0	39.0	55.0	71.0	79.0
0.1	16.1	21.8	27.6	39.0	50.4	65.7
0.2	12.3	16.8	21.2	30.1	39.0	43.4
0.3	9.9	13.5	17.2	24.4	31.7	35.3
0.4	8.2	11.3	14.4	20.5	26.7	29.8
0.5	7.0	9.7	12.3	17.7	23.0	25.3
0.6	6.1	8.4	10.8	15.5	20.2	22.5
0.7	5.3	7.4	9.5	13.7	18.0	20.5
0.8	4.7	6.6	8.5	12.3	16.1	18.0
0.9	4.2	6.0	7.7	11.2	14.7	16.4
1.0	3.8	5.4	7.0	10.2	13.4	15.0
1.2	3.1	4.5	5.9	8.7	11.4	12.8
1.4	2.6	3.9	5.1	7.5	9.9	11.1
1.6	2.2	3.3	4.4	6.6	8.7	9.8
1.8	1.9	2.9	3.9	5.8	7.8	8.8
2.0	1.7	2.6	3.4	5.2	7.0	7.9
2.2	1.4	2.3	3.1	4.7	6.3	7.2
2.4	1.3	2.0	2.8	4.3	5.8	6.5
2.6	1.1	1.8	2.5	3.9	5.3	6.0
2.8	1.0	1.6	2.3	3.6	4.9	5.6
3.0	.8	1.5	2.1	3.3	4.5	5.2

Horsepower Rating of Steam Locomotives

The horsepower ratings of steam locomotives usually refer to cylinder horsepower and are determined by the number of cylinders, area of pistons, boiler pressure and steam consumption. The following formulas based upon 1000-ft. per minute piston speed and 20.8 pound of steam per indicated horsepower have been in use and accepted as standard practice for many years. Some of the newer types of steam locomotives actually develop considerably more horsepower than shown by these formulas, due to economies obtained by improvements in locomotive designs and construction. Enough data has not yet been accumulated to revise the formulas to meet the new conditions.

HORSEPOWER RATING

SIMPLE STEAM ENGINES USING SUPERHEATED STEAM

$HP = .0229 \times P \times A$ for two cylinder engines
$HP = .0343 \times P \times A$ for three cylinder engines
$HP = .0458 \times P \times A$ for four cylinder engines

Where A = area of one piston in square inches
and P = boiler pressure in pounds per square inch

Boiler Capacity

The boiler capacity of a steam locomotive is usually rated in terms of its ability to produce the requisite amount of steam for the cylinders. Thus if the boiler is able to produce the same amount of steam as required by the cylinders at 1000-ft. per minute

piston speed it is rated a 100 per cent boiler. Likewise, if it will produce only 90 per cent of the steam required by the cylinders at 1000-ft. per minute piston speed it is rated a 90 per cent boiler.

The performance of the locomotive depends upon both the cylinder and boiler capacities and is limited by the cylinders or the boiler, whichever one has the smaller capacity.

The amount of steam a locomotive boiler is capable of producing in an hour depends upon so many variables that it is impossible to estimate the boiler capacity without adequate design data, and a knowledge of the quality of the fuel, rate of firing and condition of the boiler, etc. It has been found however that the boiler efficiency decreases as the rate of firing increases. This means that for maximum output the efficiency would be less than 50 per cent. For this reason the grate areas and fire box space in modern locomotives have been increased so that the rate of firing can be limited to less than 100 lb. coal per square foot of grate area per hour. In this way the boiler efficiency has been increased from about 60 per cent to about 75 per cent.

TABLE 6

TYPICAL WEIGHT DISTRIBUTION AND HORSEPOWER RATING PER TON ON DRIVERS FOR VARIOUS CLASSES OF STEAM LOCOMOTIVES.

CLASS	PERCENT WT ON DRIVERS	PERCENT WT OF ENGINE	PERCENT WT OF TENDER	RATED HP/TON ON DRIVERS	BOILER HP/TON ON DRIVERS
0-6-0	55.87	55.87	44.13	19.40	13.43
0-8-0	57.92	57.92	42.08	19.24	13.56
0-10-0	62.64	62.64	37.36	18.22	14.59
2-8-0	51.36	56.87	43.13	20.16	15.43
2-10-0	54.14	59.11	40.89	20.82	14.68
2-8-2	45.54	60.78	39.22	20.93	19.47
2-10-2	49.40	63.48	36.52	20.41	19.68
2-8-4	38.03	59.67	40.33	25.54	23.87
2-10-4	40.68	59.74	40.26	24.34	20.03
4-6-2	36.35	58.85	41.15	26.73	23.24
4-8-2	41.24	60.85	39.15	23.96	21.90
4-10-2	45.31	62.73	37.27	23.91	20.83
4-12-2	43.85	61.50	38.50	25.17	19.84
4-6-4	31.78	58.21	41.79	27.01	27.89
4-8-4	36.05	59.37	40.63	24.96	23.36
2-8-8-0	66.04	70.06	29.94		14.04
2-8-8-2	58.00	66.40	33.60	19.74	15.53
2-8-8-4	51.94	64.83	35.17	22.80	16.81
2-8-8-8-2	89.07	93.00	7.00		10.80

In general the heating surface of a locomotive boiler is a fair measure of its capacity, but it depends upon how the heating surface is distributed between the fire box and the tubes and flues. It is usually assumed that the fire box will produce 55-lb. of steam per square foot of heating surface per hour and the tubes and flues 8 to 10-lb. per square foot per hour on the basis of 12,000 BTU'S per pound of coal.

Up until about five years ago the boiler capacity of a locomotive could be calculated approximately by assuming 12 lb. of steam per square foot of evaporating surface. On this basis and assuming 20 lbs. of steam per indicated horsepower, a square foot of

heating surface is equivalent to .6 of a horsepower or the boiler horsepower of old line locomotives can be taken as equal to .6 × sq. ft. of heating surface. The boiler horsepowers given in the preceding table have been determined on this basis.

Distribution of Locomotive Weights

Table 6 on the preceding page in addition to giving the cylinder and boiler horsepowers also shows the weight on drivers, the weight of engine and the total weight of engine and tender. The same data is plotted in Fig. 3 which shows more clearly how the relations vary with different types of locomotives.

CHART SHOWING TYPICAL DISTRIBUTION OF WEIGHTS AND CYLINDER H.P. FOR STEAM LOCOMOTIVES HAVING VARIOUS WEIGHTS ON DRIVERS.

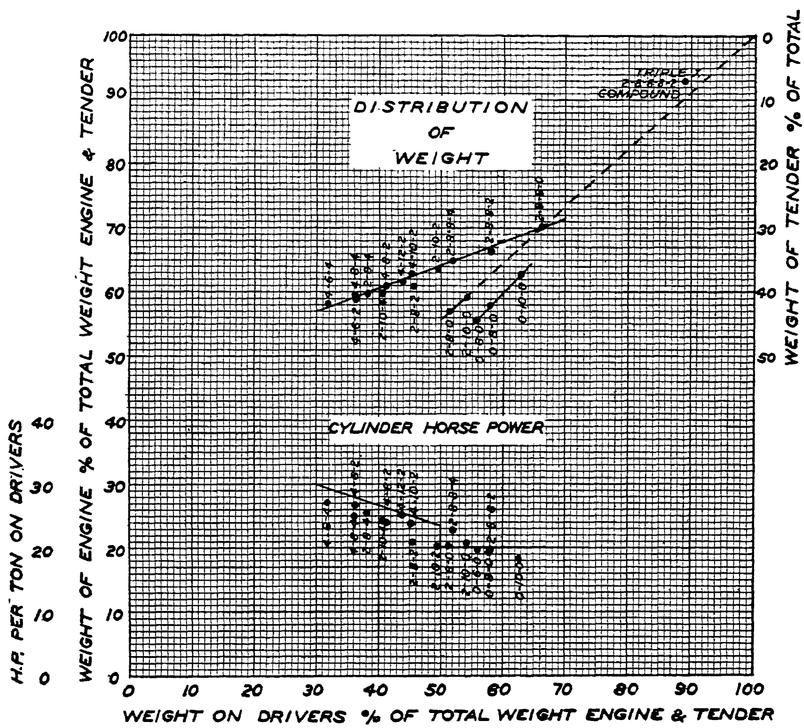


FIG. 3.

Locomotives which have the least percentage of weight on drivers are of the 4-6-4, the 4-8-4 and the 4-6-2 types which consist of four-wheel guiding trucks, three or four pairs of drivers and two or four wheel trailing trucks located under the fire box. In these designs the primary purpose of the guiding truck is to improve the tracking qualities of the locomotive at high speed. The primary purpose of the trailing truck is to provide space behind the drivers for enlarging the fire box and thus obtain greater and more efficient evaporation than could be obtained otherwise. Both trucks also support part of the weight of the boiler thereby making it possible to build larger boilers for a

given weight on drivers than can be done without them. For this reason the boiler horsepowers and likewise the cylinder horsepowers per ton on drivers are greater for these types of locomotives than for any other.

As the number of drivers increases the percentage of weight on drivers naturally increases until with articulated types of locomotives the weight on drivers may amount to 65 or 70 per cent of the total weight of locomotive. The relations found will depend upon the weight of tenders employed, the allowable weight per driving axle and the number of guiding and trailing axles. The straight line shown in Fig. 3 represents the average relation between weight on drivers and weight of tender for a large number of locomotives and allows for some increase in weight of tender with the size of locomotive.

Switching and some of the older types of freight locomotives such as Consolidations and Decapods fall into separate groups. The Triplex or 2-8-8-8-2 compound locomotive which has four driving axles and a trailing axle under the tender approaches the limiting case for these latter groups.

Chart Showing Relation Between Cylinder and Boiler H.P. for Steam Locomotives Having Various Weights on Drivers.

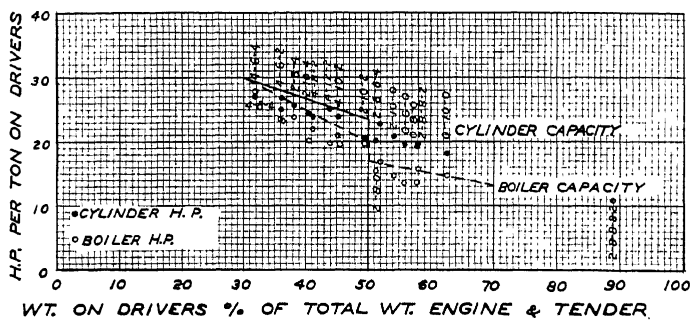


Fig. 4.

The purpose of the chart in Fig. 4 and the lower chart in Fig. 3 is to obtain a more or less rational relation between the percentage weight on drivers and the cylinder and boiler horsepower capacities obtainable in order to develop a series of tables to show typical performances of locomotives based on the percentage of weight on drivers which will take account of horsepower capacities. These charts will not apply to the new line of locomotives developed during the past five years or locomotives using oil fuel

Characteristics of Steam Locomotives

For short periods the output of a steam locomotive can be based upon its cylinder capacity regardless of its boiler capacity for the reason that the boiler has considerable storage capacity and can be "force fired" for a limited time. On the basis of continuous runs however steam locomotives can only be counted on to deliver outputs up to the capacity of their boilers. In the discussion which follows the performances are all based on continuous runs.

Speed Factors

As stated previously, the horsepower developed by a steam locomotive varies with its speed and reaches a maximum at a speed corresponding to about 1000 ft. per minute

piston speed. It has been found from theory and practice that the cylinder horsepower at piston speeds other than 1000 feet per minute can be computed by applying speed factors which have been determined experimentally and found to be applicable over a wide range of cylinder dimensions and locomotive designs.

Committee XVI—Economics of Railway Location was a pioneer in the development of speed factors based upon boiler capacity. Its report was adopted by the Association and first printed in the Manual for 1915.

The most widely used speed factors are known as Cole's ratios, which were first employed in 1914 by the American Locomotive Company. These are based on cylinder capacity and require adjusting whenever the boiler capacity is less than the cylinder capacity. It is also necessary to convert locomotive speed into piston speed or vice versa, which is readily done by substituting in the formula,

$$\text{Locomotive Speed } MPH = \frac{.01785\ DL}{S}$$

Where D = diameter of drivers in inches
L = piston speed in feet per minute
S = stroke in inches

In the preliminary stages of the problem the diameter of drivers and stroke of pistons are not always known and in order to be able to neglect these factors it is proposed to substitute an empirical formula approximating Cole's ratios as given below.

The variation in cylinder horsepower can be expressed by the formula

$$HP = K(1-e^{-nV})$$

Where K = maximum cylinder horsepower
e = Naperian base
n = constant
V = locomotive speed in m.p.h.

To find n reduce the horsepower to the basis of one ton on drivers and assume a maximum tractive effort of 30 per cent of the weight on drivers based upon a mean effective pressure equal to 100 per cent boiler pressure. Assume also that when $V = V_1$ that $nV = 1$ then by substituting in the above formula the horsepower corresponding to 100 per cent cut off (V_1) is

$$HP = K(1 - e^{-1}) = .632\ K$$

The horsepower per ton on drivers corresponding to a cylinder tractive effort of 30 per cent of the weight on drivers and the speed V_1 can also be written:

$$HP = \frac{.30 \times 2000 \times V_1}{375}$$

By equating, $V_1 = .395\ K$ and $n = \dfrac{1}{.395\ K}$

In other words, the miles per hour corresponding to the limit of full cut off is approximately equal to about 40 per cent of the rated horsepower per ton on drivers.

If the boiler horsepower is less than the cylinder horsepower then K should be expressed in terms of boiler horsepower for continuous performance.

Table 7, following, gives a comparison of the speed factors obtained by the formula with Cole's ratios, assuming that V_1 corresponds to 250 feet per minute piston speed for Cole's ratios.

TABLE 7

STEAM LOCOMOTIVE COMPARISON OF SPEED FACTORS
SUPERHEATED STEAM.

SPEED	HORSE POWER SPEED FACTORS		SPEED	HORSE POWER SPEED FACTORS	
	FORMULA	COLE		FORMULA	COLE
$V = 1.00\ V_1$	.632	.557	$V = 2.75\ V_1$	.935	
1.20 "	.699	.643	2.80 "	.939	.952
1.25 "	.714		3.00 "	.950	.963
1.40 "	.753	.713	3.20 "	.959	.975
1.50 "	.777		3.25 "	.961	
1.60 "	.798	.776	3.40 "	.967	.983
1.75 "	.826		3.50 "	.970	
1.80 "	.835	.823	3.60 "	.973	.993
2.00 "	.865	.868	3.75 "	.977	
2.20 "	.888	.895	3.80 "	.978	.997
2.25 "	.895		4.00 "	.982	1.000
2.40 "	.909	.920	4.50 "	.989	1.000
2.50 "	.918		5.00 "	.993	1.000
2.60 "	.926	.936	6.00 "	.997	1.000

Drawbar Pull

On account of the fact that the pulling power of steam locomotives is usually tested by dynamometer cars, the term "drawbar pull" has been applied to the force exerted at the drawbar of the tender. This force is less than the force acting on the pistons because of the mechanical losses in the engine and because the dynamometer car does not measure the force required to move the engine and tender.

In steam practice, it is customary to estimate the drawbar pull on tangent level track by assuming that the loss between the pistons and the drawbar for single engines amounts to 25 pounds per ton of weight on drivers plus the resistance of trucks and tender taken at an amount equal in pounds per ton to that assumed for the cars in the train. For the purpose of this discussion, it is simpler to deal with the tractive effort at the driving axles than with drawbar pull and for this reason it is assumed that the loss between the pistons and the driving axles amounts to twenty pounds per ton on drivers and the force required to move the locomotive including tender is assumed to be part of the train resistance and is taken at the same amount per ton of total weight as assumed for the cars in the train.

The horsepower loss between the pistons and the driving axles can then be calculated by the formula

$$HP \text{ Loss} = \frac{20 \times V \times W}{375}$$

Where V = speed in miles per hour
W = weight on drivers in tons (2000-lb.)

The difference between the cylinder horsepower adjusted for boiler capacity and the horsepower loss gives the net or tractive effort horsepower at the driving axles which is represented by the curve *FG*, Fig. 2, and by the series of curves in Fig. 5 showing the horsepower available at various speeds for overcoming the total resistance of the train and locomotive.

The equation of the driver horsepower curve for speeds greater than V_1 can be written as follows:

$$\text{Driver } HP \text{ per Ton on Drivers} = K(1 - e^{-nV}) - \frac{20 \times V}{375}$$

The maximum h.p. derived by differentiation of this equation is obtained when the speed is equal to $3.86 \times V_1$ at which point the mechanical efficiency obtained is about 91.7 per cent based on the formula. The mechanical efficiency varies from 96.7 corresponding to V_1 to less than 90 per cent corresponding to values of V greater than $5V_1$.

Characteristic Speed Tractive Effort Curves

The speed tractive effort curves shown in Fig. 5, page 568, are based on the net or tractive effort horsepower at the driving axles. The dotted portions indicate theoretical values based upon a mean effective pressure at full cut-off equal to 100 per cent of the boiler pressure instead of about 85 per cent commonly used. In practice, the curves round off as indicated by the solid lines, but since it is possible to equip modern locomotives with either a booster or an auxiliary engine, it can be assumed that the theoretical values shown are obtainable. As a matter of fact, it is possible by stretching a point to even exceed the theoretical values for some classes of locomotives equipped with boosters. For example, the tractive effort supplied by boosters on 4–6–4 and 4–8–4 types may amount to more than 20 per cent of the tractive effort supplied by the main drivers.

A convenient form for tabulating the calculations is illustrated by Table 8, page 569, which shows both the short time and continuous output capacities. All of the typical curves are based upon 100 per cent boiler capacity and corrected for mechanical losses based on 20 pounds per ton on drivers. The tractive effort curves therefore show the forces available for overcoming train resistance from which the free running or balanced speed on any grade for any weight train can be calculated.

Thus a locomotive having a rating of 30 horsepower per ton on drivers if equipped with a 100 per cent boiler would develop a tractive effort of 166 pounds per ton on drivers at 60 m.p.h. If the train resistance amounted to 12 pounds per ton on level track then the maximum weight of train which could be handled at 60 miles per hour would be 166/12 or 13.8 tons total per ton on drivers. As seen from Fig. 4 a locomotive rated 30 h.p. per ton on drivers will have only 30 per cent of its weight on drivers, or in other words, the locomotive will weigh 3.3 tons for every ton on drivers, hence the trailing tons will amount to 13.8 — 3.3 or 10.5 tons which is 3.2 times the weight of the locomotive.

On the same basis a locomotive having a rating of 23.5 horsepower per ton will have according to Fig. 4 fifty per cent of its weight on drivers and a boiler capacity of 20 horsepower or 85 per cent. The performance of such a locomotive for purposes of illustration would be the same as a locomotive rated 20 horsepower per ton on drivers with a boiler capacity of 100 per cent. Such a locomotive would develop a tractive effort of 105 pounds per ton on drivers at 60 m.p.h., which is equivalent to the train resistance of 8.75 tons on the basis of 12 pounds per ton. Since the locomotive weighs only two tons per ton on drivers the trailing weight is 6.75 tons or 3.38 times the weight of locomotive or slightly more than found in the previous case.

Similarly the trailing weight for various classes of locomotives can be obtained for any speed on any grade.

Theoretical Maximum Trailing Ton Miles per Hour

The values of trailing train weight found as described above and multiplied by the corresponding speed in miles per hour will give a measure of the gross ton miles per hour obtained under various conditions of operation. The conditions of train weight and speed which will produce the greatest gross ton miles per hour can be obtained by plotting the product of trailing weight and speed against the corresponding values of speed

TYPICAL STEAM LOCOMOTIVE CHARACTERISTIC CURVES—100 PER CENT BOILER CAPACITY.

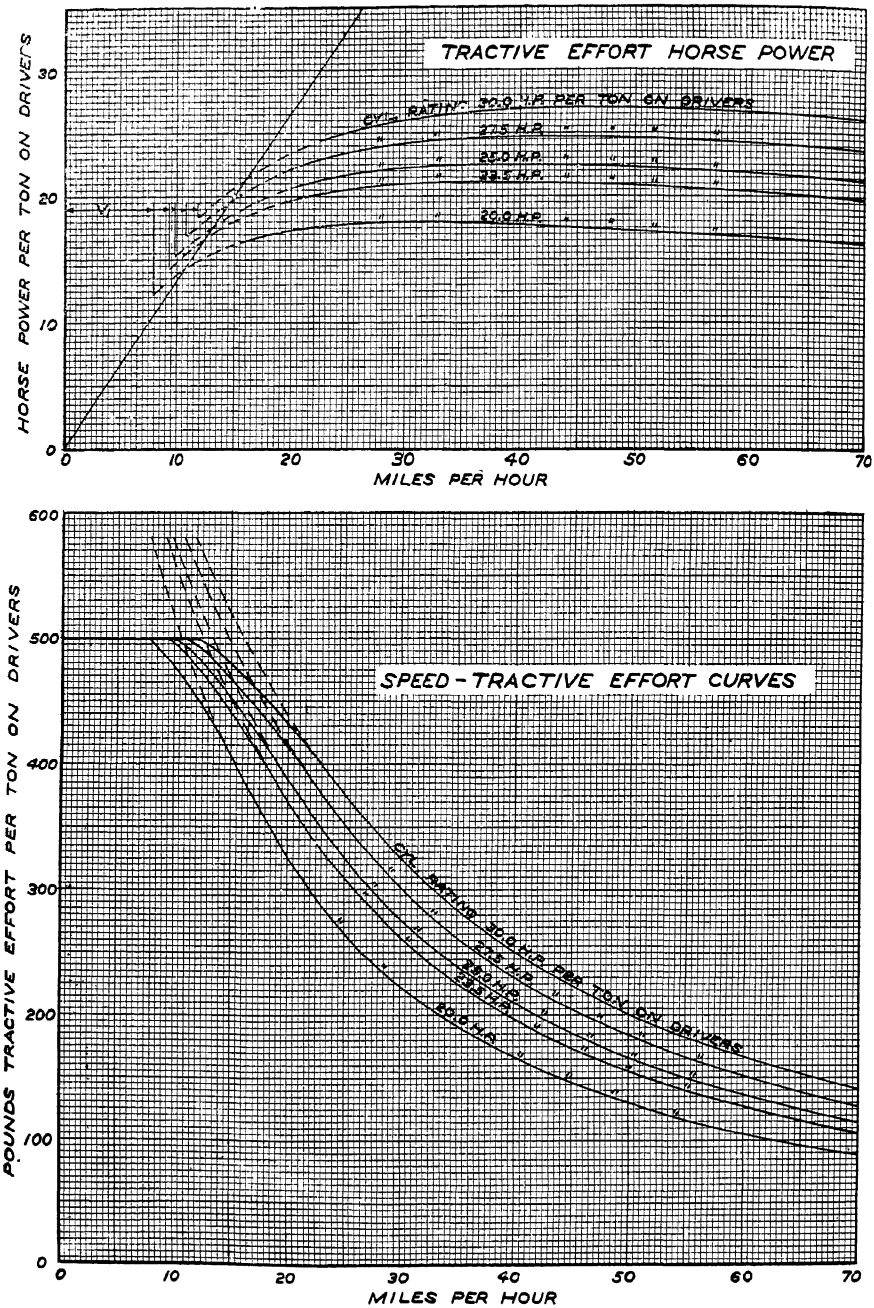


FIG. 5.

TABLE 8

FORM SUGGESTED FOR CALCULATING HORSEPOWER AND SPEED TRACTIVE EFFORT CURVES

STEAM LOCOMOTIVES

Example Based on 26.8 cyl. h.p. Per Ton on Drivers
93.3 Per Cent Boiler Capacity

Speed			Speed	Horse Power		H.P. Less		Net H.P.		Tractive Effort	
V.	M.P.H.	Adj.	Factor	Cyl.	Boiler	Cyl.	Boiler	Cyl.	Boiler	Per Ton*	Total
1.00 V-	10.60	9.90	.632	16.94	15.80	.565	.528	16.375	15.272	580	
1.25 "	13.25	12.37	.714	19.14	17.85	.707	.660	18.333	17.190	522	
1.50 "	15.90	14.85	.777	20.82	19.43	.848	.792	19.972	18.638	471	
1.75 "	18.55	17.32	.826	22.14	20.65	.989	.924	21.151	19.726	428	
2.00 "	21.20	19.80	.865	23.18	21.63	1.131	1.056	22.049	20.574	390	
2.25 "	23.85	22.27	.895	23.99	22.38	1.272	1.188	22.718	21.192	357	
2.50 "	26.50	24.75	.918	24.60	22.95	1.413	1.320	23.187	21.630	328	
2.75 "	29.15	27.22	.935	25.06	23.38	1.555	1.452	23.505	21.928	302	
3.00 "	31.80	29.70	.950	25.46	23.75	1.696	1.584	23.764	22.166	280	
3.25 "	34.45	32.17	.960	25.73	24.00	1.837	1.716	23.893	22.284	260	
3.50 "	37.10	34.65	.970	26.00	24.25	1.979	1.848	24.021	22.402	243	
3.75 "	39.75	37.12	.977	26.18	24.43	2.120	1.980	24.060	22.450	227	
4.00 "	42.40	39.60	.982	26.32	24.55	2.261	2.112	24.059	22.438	213	
4.50 "	47.70	44.55	.989	26.51	24.73	2.544	2.376	23.966	22.354	188	
5.00 "	53.00	49.50	.993	26.61	24.83	2.827	2.640	23.783	22.190	168	
6.00 "	63.60	59.40	.997	26.72	24.93	3.392	3.168	23.328	21.762	137	

V_1 = .395 x rated cylinder h.p. = .395 x 26.8 = 10.60

Adjusted speed = V_1 x boiler capacity

* Per ton on drivers

Speed factors obtained from table

Cyl. H.P. = Rated h.p. x speed factor

Boiler H.P. = Cyl. h.p. x boiler capacity

H.P. Loss = $\frac{20 \text{ x m.p.h.}}{375}$

Net H.P. = Cyl. h.p. - n.p. loss or boiler h.p. - h.p. loss

as illustrated by the charts in Fig. 6 and 7. Figure 6 is based upon a locomotive having 30 per cent of its weight on drivers and boiler and cylinder capacities of 30 horsepower per ton on drivers.

One of the points it is desired to illustrate by this chart is the fact that in order to obtain the maximum gross ton miles per hour with a locomotive of this type it is necessary under some conditions to employ the booster in continuous operation because the tractive effort corresponding to the speed at that point is above the tractive effort developed by the main drivers. See Fig. 5. This is a condition which would be more or less expected in the case of essentially passenger locomotives.

Chart Showing Relation Between Miles Per Hour and Gross Ton Miles Per Hour on Various Grades Based on Typical Locomotive Having 30 Per Cent of Its Weight on Drivers With 100 Per Cent Boiler Capacity and Rated Capacity of 30 h.p. Per Ton on Drivers.

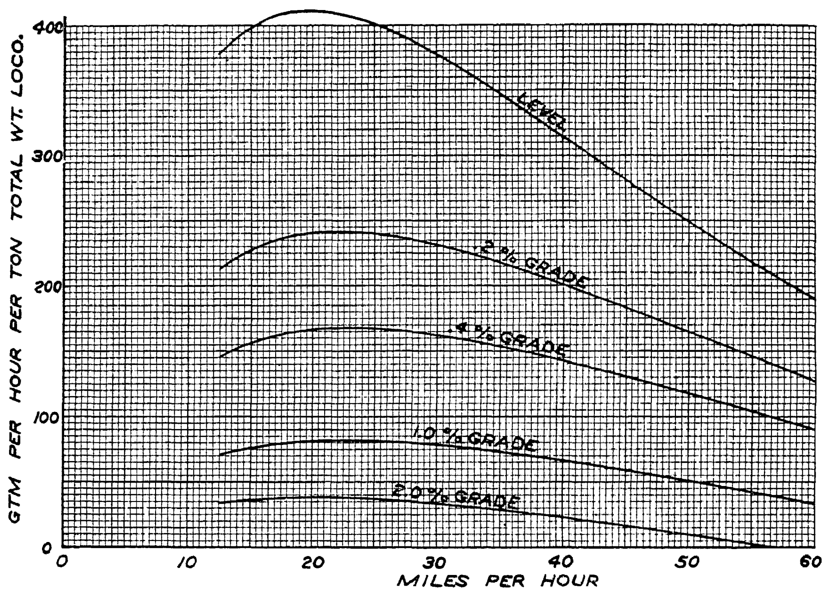


Fig. 6.

In the case of freight locomotives, Fig. 7 which is based upon a locomotive having 50 per cent of its weight on drivers, an 85 per cent boiler and cylinder capacity of 23.5 horsepower per ton on drivers, the maximum gross ton miles per hour is obtained at speeds which correspond to tractive efforts below the slipping point of the main drivers, hence it is not necessary to employ the booster continuously.

The equation for finding the gross ton miles per hour per ton weight of locomotive for any speed may be written as follows:

$$G.T.M.\text{ per hour per ton wt. of loco.} = \frac{P}{R}\left[375 \times K\,(1 - e^{-nV}) - 20 \times V\right] - V$$

Where P = per cent weight on drivers
R = train resistance in lbs. per ton
n = constant $= \frac{1}{V_1}$
K = boiler horsepower per ton on drivers
V = speed in miles per hour

If R is independent of V the above expression is easily differentiated and the speed V corresponding to the maximum gross ton miles per hour can be found.

$$V_m = V_1 \log_e \frac{950P}{20P + R} \text{ or } 2.3\ V_1 \log_{10} \frac{950P}{20P + R}$$

On heavy grades train resistance (R) varies only slightly with change in speed, hence it is proper to use the formula to find the speed corresponding to the maximum gross ton miles per hour. On light grades and level track, train resistance varies considerably with changes in speed which makes it difficult to derive a formula to fit this condition,

Chart Showing Relation Between Miles Per Hour and Gross Ton Miles Per Hour on Various Grades Based on Typical Locomotive Having 50 Per Cent of Its Weight on Drivers With 85 Per Cent Boiler Capacity and Rated Capacity of 23.5 h.p. Per Ton on Drivers.

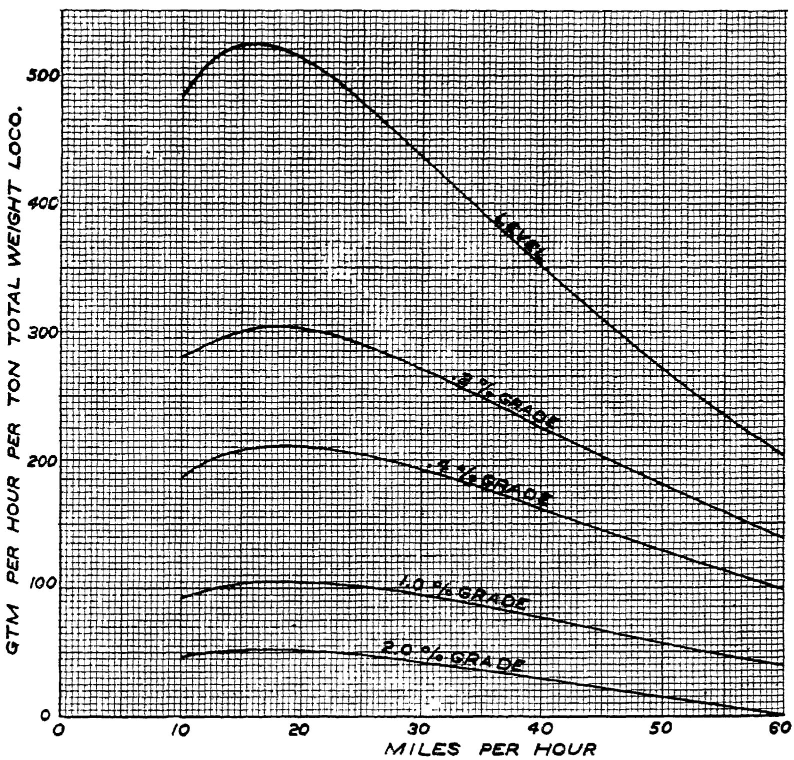


Fig. 7.

but for various reasons, results obtained by the formula have a practical value in determining tonnage ratings on any grade, because the errors introduced are about sufficient to offset the greater difficulty experienced in starting maximum trains on light grades than on heavy grades. In other words, the true maximum gross ton miles per hour on level track for example is so near the limit of adhesion that little power is available for accelerating the train and any unfavorable conditions are liable to cause stalling. When the formula is used a workable margin is provided which is about what is required for successful operation.

The equation $V = V_1 \log \frac{950 \times P}{20P + R}$ is not easily solved directly and the form, Table 9, Part I is suggested for calculating 8 or 10 values of R corresponding to selected values of V_m. From these values of R the train resistance corresponding to V_m is subtracted leaving the resistance due to grade from which the per cent grade can be obtained. By plotting the per cent grades against the corresponding values of V_m curves similar to those in Fig. 8 are obtained.

CHART SHOWING MAXIMUM GROSS TON MILES PER HOUR WEIGHT OF LOCOMOTIVE ON VARIOUS GRADES; ALSO THE CORRESPONDING SPEEDS BASED ON 35 PER CENT OF TOTAL WEIGHT ON DRIVERS 28.4 CYLINDER H.P./TON ON DRIVERS 27.5 BOILER H.P./TON ON DRIVERS.

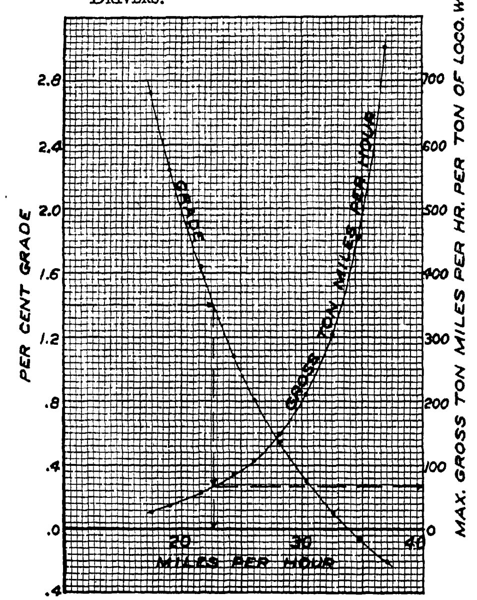


FIG. 8.

The equation for gross ton miles per hour per ton of locomotive for old line locomotives may be written

$$GTM/HR \text{ per ton wt. of Loco.} = \frac{P}{R} (375 \times K \times \text{Speed Factor} - 20V) - V$$

TABLE 9

FORM SUGGESTED FOR ARRANGEMENT OF CALCULATIONS
TO OBTAIN MAXIMUM GROSS TON MILES PER HOUR AND THE CORRESPONDING SPEED

PART I

Item			*Example*
1	Boiler HP Per Ton on Drivers (K)		*27.5*
2	Speed Corresponding to Full Cutoff (V_1)	.395K	*10.86*
3	*Per Cent Wt. on Drivers (P) Corresponding to K		*35*
4	Assume 8 to 10 Values of $\frac{Vm}{V_1}$ as Shown in Col. (b)		
5	Plot (a) and (h) See Fig. 8.		

Vm	$\frac{Vm}{V_1}$	Anti-Log_e (b)	$\frac{950 \times P}{(c)}$	R = (d) - 20P	Train Res. Level	Grade Res. (e) - (f)	Per Cent Grade
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
17.38	1.60	4.95	*67.20*	*60.20*	*5.82*	*54.38*	*2.72*
19.00	1.75	5.76	*57.70*	*50.70*	*6.00*	*44.70*	*2.24*
21.72	2.00	7.39	*45.00*	*38.00*	*6.25*	*32.75*	*1.64*
24.44	2.25	9.49	*35.05*	*28.05*	*6.55*	*21.50*	*1.08*
26.06	2.40	11.02	*30.15*	*23.15*	*6.72*	*16.43*	*.81*
28.24	2.60	13.46	*24.70*	*17.70*	*6.97*	*10.73*	*.54*
30.41	2.80	16.45	*20.20*	*13.20*	*7.22*	*5.98*	*.30*
32.58	3.00	20.08	*16.55*	*9.55*	*7.53*	*2.02*	*.10*
34.75	3.20	24.54	*13.55*	*6.55*	*7.80*	*- 1.25*	- *.06*
36.92	3.40	29.96	*11.10*	*4.10*	*8.10*	*- 4.00*	- *.20*

* See Fig. 1.

PART II

Vm	$\frac{Vm}{V_1}$	Speed Factor	375 x K x (c)	20 x (a)	(d) - (e) · (f)	$\frac{P}{R}$	(f) x (g)	(h) - (a)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
17.38	1.60	.798	*8,230*	*347.6*	*7,882.4*	.0057	*44.93*	*27.55*
19.00	1.75	.826	*8,519*	*380.0*	*8,139.0*	.0069	*56.16*	*37.16*
21.72	2.00	.865	*8,921*	*434.4*	*8,486.6*	.0092	*78.08*	*56.36*
24.44	2.25	.895	*9,230*	*488.8*	*8,731.2*	.0125	*109.14*	*84.70*
26.06	2.40	.909	*9,375*	*521.2*	*8,853.8*	.0151	*133.69*	*107.03*
28.24	2.60	.926	*9,550*	*564.8*	*8,985.2*	.0198	*177.91*	*149.67*
30.41	2.80	.939	*9,684*	*608.2*	*9,075.8*	.0265	*240.51*	*210.10*
32.58	3.00	.950	*9,797*	*651.6*	*9,145.4*	.0367	*335.64*	*303.06*
34.75	3.20	.959	*9,890*	*695.0*	*9,195.0*	.0534	*491.01*	*456.26*
36.92	3.40	.967	*9,973*	*738.4*	*9,234.6*	.0854	*788.63*	*751.71*

Plot (a) and (i). See Fig. 8.

Figures in Italics illustrate the procedure and refer to the specific example defined by items 1, 2, and 3.

By substituting the values of V_m and R found above for V and R in the latter formula and applying the speed factors from Table 1, pp. 549, 550, 551, corresponding to ratios in column B the max. gross ton miles per hour per ton wt. of locomotive can be found. Refer to Table 9, Part II, of suggested form for arrangement of calculations.

New Types in Locomotive Designs and Construction

The chief difference between the new and old designs of steam locomotives is in the size of firebox and grate area. This difference calls for two axles under the firebox instead of one so that the following 4-6-4, 4-8-4 and 4-10-4, also 2-8-4 and 2-10-4 may be regarded as new line locomotives. These locomotives also contain many other improvements not shared by old line locomotives.

It will be seen from inspection of Fig. 3 that the weight on drivers for the five types mentioned above ranges between 30 and 40 per cent of the total weight of locomotive including tender. The weight on drivers for corresponding types of the old line locomotives ranges between 35 and 50 per cent of the total weight of locomotive and tender. In other words, the addition of another axle under the firebox has made it possible to increase the weight of the engine excluding tender without increasing the weight on drivers. By so doing it has been possible to increase the size of the boiler and improve its efficiency which means a double gain in capacity. In order to make use of this additional capacity, it has been necessary to increase the output of the cylinders which has been brought about by the introduction of limited cut-off features and the adoption of higher boiler pressures.

Comparatively little data concerning these locomotives is available at this time, but that which is available indicates that a considerable increase in locomotive output has been obtained which is not apparent from the application of Cole's ratios. Looking at the problem in the light of the foregoing discussion, it is possible to see certain trends which will have to be taken into account when new motive power is considered.

In the first place, the trend compared with old line locomotives will be towards designs having a less percentage of their weight on drivers and more capacity per ton on drivers, that is one can look for a dividing line between new and old designs at about 40 per cent for the weight on drivers similar to the dividing line between rigid frame and articulated locomotives. This trend is tentatively shown in Fig. 1, page 547, of this report.

For the purposes of illustration, it has been assumed that a 4-6-4 locomotive having 30 per cent of its weight on drivers will be able to develop 40 h.p. per ton on drivers and will carry a 100 per cent boiler, and that a 4-10-4 locomotive having 40 per cent of its weight on drivers will be able to develop 31 h.p. per ton on drivers and will carry about a 93 per cent boiler. These figures have been arrived at by assuming 15 per cent greater boiler output and 15 per cent better steam economy than accounted for by Coles Ratios.

Development of New Formulas

In the previous discussion it has been shown that the equation $HP = K(1 - e^{-nV})$ approximates Cole's speed factors when $n = \frac{1}{V_1}$ and where $V_1 = .395K$. It has been found that V_1 obtained in this manner approximates 250 ft. per minute piston speed for a wide variety of locomotive designs up to locomotive capacities of about 30 horsepower per ton on drivers.

In some cases where the stroke and diameter of drivers is known the speed V_1 corresponding to 250 ft. per minute can be calculated by substituting in the following formula

$$V = \frac{.01785 \times D \times L}{S}$$

Where V = locomotive speed in miles per hour
D = diameter of drivers in inches
L = piston speed in feet per minute
S = stroke in inches

Having found V_1 and knowing the maximum horsepower developed per ton on drivers K proceed as follows to determine n

As previously stated, when $V = V_1$ the horsepower developed is assumed to correspond to a tractive effort equal to 30 per cent of the weight on drivers times V_1 divided by 375 or

$$K\,(1 - e^{-nV}) = \frac{.30 \times 2000 \times V_1}{.375}$$

$$1 - e^{-nV_1} = \frac{600}{375} \times \frac{V_1}{K}$$

$$nV_1 = \log \frac{1}{1 - \frac{600}{375} \times \frac{V_1}{K}} = M$$

$$n = \frac{M}{V_1}$$

For example assume $V_1 = 12$ and $K = 40$ then

$$nV_1 = \log \frac{1}{1 - \frac{600}{375} \times \frac{12}{40}}$$

$$= \log 1.923 = .654$$

$$n = \frac{.654}{V_1}$$

By substituting this value of n in the expression $(1 - e^{-nV})$ the following speed factors can be obtained from tables giving values of e

Horsepower Speed Factors

By Formula $HP = K\,(1 - e^{\frac{-.654V}{V_1}})$

Speed	*Speed Factor*	*Speed*	*Speed Factor*	*Speed*	*Speed Factor*
$V = 1.0V_1$	.480	$V = 3.0V_1$	.860	$V = 5.0V_1$	.960
$1.5V_1$	.625	$3.5V_1$	.900	$6.0V_1$	.980
$2.0V_1$	.730	$4.0V_1$	.928	$7.0V_1$	.990
$2.5V_1$	.803	$4.5V_1$	.947	$8.0V_1$	.995

By substituting the value of $n = \frac{.654}{V_1}$ for $\frac{1}{V_1}$ in the discussion on page 565 the maximum driver horsepower is obtained when the speed is equal to $5.67 \times V_1$ or 68 MPH which corresponds to 1400 ft. per minute piston speed instead of 1000 ft. for old line locomotives.

REPORT OF COMMITTEE VIII—MASONRY

MEYER HIRSCHTHAL, *Chairman;*
J. T. ANDREWS,
F. E. BATES,
H. I. BENJAMIN,
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T. L. CONDRON,
HARDY CROSS,
W. F. CUMMINGS,
THEO. DOLL,
G. F. EBERLY,
L. V. HAEGERT,
J. L. HARRINGTON,
A. D. HARVEY,
W. K. HATT,
A. C. IRWIN,
A. R. KETTERSON,
J. A. LAHMER,
A. N. LAIRD,
O. V. PARSONS,
C. P. RICHARDSON,
D. A. RUHL,
D. B. RUSH,
F. E. SCHALL,
C. P. SCHANTZ,
L. W. SKOV,
J. F. LEONARD, *Vice-Chairman;*
G. R. SMILEY,
A. W. SMITH,
G. L. STALEY,
I. F. STERN,
G. E. TEBBETTS,
H. H. TEMPLE,
L. W. WALTER,
C. A. WHIPPLE,
C. C. WILLIAMS,
D. E. WOOZLEY,
W. K. WYATT,
J. J. YATES,
Committee.

To the American Railway Engineering Association:

Your Committee on Masonry respectfully presents herewith report covering the following subjects:

1. Revision of Manual (Appendix A).
2. Specifications and principles of design of plain and reinforced concrete (Appendix B).
3. Progress in the science and art of concrete manufacture (Appendix C).
8. Specifications for repairing deteriorating concrete (Appendix D).
9. Design of expansion joints involving masonry structures (Appendix E).

The Committee reports progress on

4. Contact with Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.
5. Specifications for foundations.
6. Methods and practices of lining and relining tunnels.

Action Recommended

1. That the change in the Manual in Appendix A be approved for printing as revised material for the Manual.
2. That Appendix D be approved for printing in the Manual as recommended practice.
3. That Appendices B, C, and E be received as information.

Respectfully submitted,

THE COMMITTEE ON MASONRY,

MEYER HIRSCHTHAL, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. F. Leonard, Chairman, Sub-Committee; Theo. Doll, G. F. Eberly, A. C. Irwin, J. A. Lahmer, A. N. Laird, C. P. Richardson, D. B. Rush, L. W. Walter, C. A. Whipple, J. J. Yates.

Your Committee recommends the adoption of the following revisions of and additions to the present recommended practices now appearing in the Manual:

Bulletin 353, January, 1933.

PROPOSED REVISIONS OF SPECIFICATIONS FOR PORTLAND CEMENT CONCRETE, PLAIN AND REINFORCED

Present Article 8 (page 567)

Mixing water shall be free from oil, acid, and injurious amounts of vegetable matter, alkalies, or other salts.

Proposed Article 8

Mixing water shall be free from oil, acid, and injurious amounts of silt, vegetable matter, alkalies, or other salts.

Present Article 10, page 568

". . . . . ."

Structural steel shapes used for reinforcing shall conform to the requirements of the American Railway Engineering Association's Specifications for Steel Railway Bridges.

Proposed Article 10

". . . . . ."

Structural steel shapes used for reinforcement shall conform to the requirements of the American Railway Engineering Association's Specifications for steel for the corresponding type of structure.

Present Article 13, page 568

Wire for concrete reinforcement shall be cold drawn steel wire.

Proposed Article 13

Wire used for concrete reinforcement shall conform to the current specifications of the American Society for Testing Materials for "cold drawn steel wire for concrete reinforcement" (Serial Designation A-82-21).

Article 14, page 568, Add

Wire shall conform to the provision of Article 13.

Present Article 59, page 577

Joints in columns shall be made at the underside of the floor. Haunches and column capitals shall be considered as part of and to act continuous with the floor. At least two hours must elapse after depositing concrete in the columns or walls before depositing in beams, girders, or slabs.

Proposed Article 59

Joints in columns shall be made at the underside of the floor. Haunches and column capitals shall be considered as part of and to act continuous with the floor.

Present Article 63, page 577

"(. . . . . .)".

Proposed Article 63

Where construction joints are required to be water-tight, a continuous keyway shall be constructed in the face of the first section of concrete placed, and continuous sheet of non-corrosive metal not less than 12″ wide placed so as to extend the full length of the joint and be embedded equally in the concrete on each side thereof. Before continuing with the placement of concrete, the joint shall be thoroughly cleaned of laitance or other foreign material and saturated with water. The concrete shall then be placed in such a manner as will insure an excess of mortar over the entire surface of the joint.

Present Article 64, page 577

"(. . . . . .)".

Proposed Article 64

Concrete required to be water-tight shall be made with strict adherence to all provisions in these specifications regarding the choice of materials, proportions, con-

sistency, mixing, placing, protection and workmanship. The quantity of water used per sack of cement shall be the minimum consistent with workability and the requirements for placing.

Present Article 72, page 579

"(. . . . . .)".

Proposed Article 72

The following requirements, in addition to the provisions hereof applying to forms, mixing, conveying, depositing, etc., except as modified by the plans or by the direction of the Engineer, shall be applicable to the construction of concrete surfaces exposed upon the completion of the structure:

(a) All face forms shall be smooth and water-tight. If of wood, the face boards shall be sized to a uniform thickness and all offsets or inequalities dressed to a smooth surface. They shall be tightly placed and all openings and cracks pointed flush, as directed by the Engineer, to prevent leakage and the formation of fins. Forms shall be so constructed that they can be removed without hammering or prying against the concrete surface.

(b) Exposed surface shall be cast in one continuous operation between prescribed construction limits. Construction and expansion joints not shown on the plans shall be made only as directed by the Engineer and shall be true to line with sharp unbroken edges, beveled or rounded as specified.

(c) The same brand of cement and the same kind and size of aggregate shall be used throughout the whole of any exposed surface.

(d) The concrete shall be so mixed, placed, and worked with a spading tool that the aggregate is uniformly distributed and a full surface of mortar brought against the form free from air pockets and void spaces. If the finish is to be one that will expose the coarse aggregate by either rubbing, tooling, sandblasting or acid treatment, then after the full surface of mortar has been worked against the form, the coarse aggregate shall be spaded against the form, to secure a uniform distribution at the face and a uniform mixture of the exposed aggregate in the finished surface.

(e) The forms shall be carefully removed from the surfaces as early as practicable, and all fins, joint marks, projections, and inequalities chipped off. If there should be found any small pits or openings in the exposed surface of the concrete or if bolts are used for securing the forms the ends of which on removal leave small holes, the surface shall be thoroughly saturated with water and all such holes, pits, etc., shall be neatly stopped with pointing mortar of cement and fine aggregate in the same proportion as used in the concrete, and smoothed even with the surface with a wooden float. The mortar shall be mixed in small quantities and shall be used while still plastic.

All such work in connection with the correction of damaged sections, voids or honeycomb shall be performed under the direction of the Engineer.

(f) No mortar or cement shall be applied to the surface except to fill pits or voids, tie bolt holes, etc., as above provided. Uneven places shall be smoothed by rubbing down as hereinafter provided and not by plastering.

(g) Whenever the forms are removed before the concrete has properly set the surface shall be immediately wetted and kept wet for not less than three days.

Present Article 84, page 581

"(. . . . . .)".

Proposed Article 84

(d) The moduli of elasticity of concrete in computations for the position of the neutral axis, for the resisting moment of beams, and for compression of concrete in columns, shall be assumed as follows:

(1) 1/15 that of steel, when the design is based on a compressive strength of concrete at 28 days of 2000 lbs. per square inch.

(2) 1/12 that of steel when the design is based on a compressive strength of concrete at 28 days of 2500 lbs. per square inch.

(3) 1/10 that of steel, when the design is based on a compressive strength of concrete at 28 days of 3000 lbs. per square inch.

(4) 1/8 that of steel when the design is based on a compressive strength of concrete at 28 days of 3500 lbs. per square inch.

Appendix B

(2) SPECIFICATIONS AND PRINCIPLES OF DESIGN OF PLAIN AND REINFORCED CONCRETE

A. N. Laird, Chairman, Sub-Committee; J. F. Leonard, F. E. Bates, T. L. Condron, Hardy Cross, J. L. Harrington, A. C. Irwin, A. R. Ketterson, C. P. Schantz, L. W. Skov, A. W. Smith, I. F. Stern, C. C. Williams.

(a) The Committee presents a design for a ballasted deck reinforced concrete trestle with sections and details contained in Fig. 1 to 7 inclusive. This is presented as information.

(b) While the Committee is not in a position to present a specification for the design of reinforced concrete structures as rigid frames, there is presented herewith a monograph on the subject by one of its members. This is presented as information.

(c) The Committee reports progress on the subject of Specifications for Concrete Arches.

(d) The revisions of Concrete Specifications is presented by Sub-Committee 1 as revisions of the Manual.

Section A

RIGID FRAME BRIDGES

By Professor Hardy Cross

General Characteristics

A relatively new type of structure known as the rigid frame bridge has appeared in American practice. It offers attractive architectural possibilities, and because it may be made very thin at the center it saves yardage of cut or fill in the approaches of over or undercrossings. The type is not, however, as new as is sometimes supposed. A letter from A. A. Brielmaier in Civil Engineering for October, 1932, cites European examples dating back to 1904. There is apparently good evidence to support the claims for economy of this type in certain cases. Great rigidness has also been claimed; this term is not very definite, but if small deflection under live load is meant, there is good reason to think that the claim is not well founded.

The term "rigid frame bridge" is often used with some vagueness; for present purposes we may define such a bridge as one in which the determination of the strength of the structure is based on the continuity obtained by making the girders structurally integral and continuous with the columns or piers and often with the abutments.

Continuity with the abutments is suggested partly to reduce the positive moment in the end span and partly to reduce the size of the abutments by changing them from cantilever structures to beams supported and at least partly fixed at top and bottom. This results in some saving of yardage both of concrete and of excavation but replaces mass concrete by reinforced concrete.

The restraint offered to the ends of the girder by the heavy abutments and piers makes them act merely as beams fixed at the ends, since, at least for highway loading, the dead load is much greater than the live load, satisfactory preliminary designs may be made by treating the girders as fixed-end beams subject to dead load. But in girders fixed at ends, the center moment is much smaller than at the supports, hence the soffits may be curved, thus reducing the dead load, and reducing the required depth at the end.

Continuity of girders with piers reduces the maximum positive moments in the girders, but throws into the columns or piers objectionable bending stresses. If the columns are slender these stresses are not serious, but such columns lack rigidity against traction thrusts. If the columns are made deeper the flexural stresses in them become serious unless they are made wide enough to be essentially girders, as they often are.

Uncertainties as to Structural Action

This type of structure evidently involves some uncertainties as to its action, of which the following are the most important.

(a) Uncertainties as to modulus of elasticity. The value of E affects directly the stresses produced by changes of temperature by shrinkage and by movement of foundations. For given proportions of the structure, the distortions produced by given changes in length are fixed. But the stresses corresponding to these distortions vary directly with the modulus of elasticity. As is now well understood, this quantity may vary for instantaneous effects from 2,000,000 lb. per sq. in. to 4,000,000 lb. per sq. in., though values higher and lower than these are occasionally found, the exact value depending somewhat on the amount of deformation but chiefly on chance. For distortions produced gradually or for stresses long continued, the ratio of stress to strain is much reduced by flow of the concrete.

(b) Uncertainties as to earth pressure. The earth pressures against the abutments may equal the active earth pressure; if the earth shrinks away from the abutment they may be zero; if the bridge expands into the fill or tends to swing laterally under unbalanced load, they may be greater than the active pressure. These uncertainties affect the design of the reinforcement in the abutments more than they do the design of the girders.

(c) Uncertainties as to foundation distortions. The foundations may not be entirely fixed. The footings may settle vertically, they may rotate or they may spread horizontally. If both footings settle vertically by the same amount no harm is done to the structural frame and small differential settlements are not especially dangerous. Small rotations of the footings change very much the curves of moments on the abutments but they do not affect seriously the moments in the girders. But small horizontal movements of the abutments seriously endanger the stability of the girder, this being especially important in short spans. If there were no horizontal reactions in the abutments, there would be almost no bending in the abutments and the girder would act as a beam simply supported.

Special attention should therefore be given to the horizontal stability of the footings, the more so the shorter the span. In this respect the structural type is similar to the arch; indeed the type in which the girder is continuous with the abutments is essentially an arch in which the axis is improperly shaped for its dead load polygon, the change in shape being dictated by considerations of clearance and by convenience of construction.

Attention should be directed to the sensitiveness of the positive moments at the center of the span to variations in assumptions as to the action of the structure, especially where the soffits of the girders are curved. The computed moments at the center have been reduced by perhaps eighty per cent or more as a result of continuity and any variation in this reduction represents a relative error many times as great in the positive moment. The chief source of danger from this cause is the continued spread of the footings under the action of the dead load. With such large effects on the positive moments from spread, the factor of safety against failure at the center of the girder needs full consideration. This type of structure seems ill adapted to unstable foundations. In any case apparently about the best that can be done after giving careful attention to the design of the foundations, is to estimate possible displacements and include their effects as elements in the design.

(d) Uncertainty as to relative stiffness of the members. This is especially significant in determining the relative stiffness of piers or abutments and of T-beams. It is

clear that the term EI used in analyses of continuous frames is a physical constant, not a mathematical abstraction. It is the rotation per unit of bending moment for a unit length and in T-beams the prediction of this quantity is very difficult.

For rectangular beams it is probably satisfactory to assume a moment of inertia equal to that of the full transformed section.

For T-beams the following methods of computing the moment of inertia have been suggested:

(1) Moment of inertia of full transformed area of cross-section including full width of flange to center lines between adjacent girders. This, in the writer's opinion, pretty closely represents the facts.

(2) Moment of inertia of full transformed area of cross-section including permissible flange widths specified for design. This has apparently no logical basis.

(3) Moment of inertia based on the transformed area of the stem only, neglecting the overhanging flange, this value to be multiplied by a constant to allow for the effect of the flange. The simplicity of the method makes it valuable in preliminary design. The constant multiplier may be taken as five.

The effect of the uncertainty as to relative values of I indicated is not as serious as might at first appear.

Design

The following recommendations are made as a basis for design:

Preliminary Design.—It is recommended that in the preliminary design of the girders they be treated as fixed at ends.

Where, in such structures, it is desired to curve the soffits of the girders to gain clearance or for other reasons, these girders should also be treated as beams fixed at the ends.

Loads.—Such structures shall be designed for combinations of the following loads and distortions:

(a) Dead Load.
(b) Live load systems as specified for railway or for highway bridges.
(c) Distortions for change of temperature.*
(d) Distortion from volume changes in setting, equivalent to temperature change of 20° F.**
(e) 1. Full active earth pressure against the abutments.
 2. No earth pressure against the abutments.
(f) Vertical and rotational movements of the foundations, estimated on the basis of the characteristics of the foundation.

Working Stresses.—For combinations of live load, dead load and earth pressure, the working stresses prescribed in the general specifications for concrete structures shall be used. For combinations including distortions from change of temperature and shrinkage, an increase in allowable working stresses of 25 per cent shall be permitted. For combinations including also foundation distortions an increase in allowable working stresses of 33⅓ per cent shall be permitted. In all cases the maximum section determined by any of the combinations indicated shall be provided.

Assumptions in Analysis.—The moments, shears and longitudinal forces produced in such structures shall be determined by analyses based on the theory of elasticity. The

* At 40° latitude and sea level the variation from normal to be assumed shall be plus or minus 40°F. For other latitudes and exposures this figure should be modified for such conditions.

** Where methods of construction are used to eliminate this effect, this distortion need not be included.

moment of inertia of each section shall be taken as that of the full transformed section, the section of girders to include the slab for a width halfway to adjacent parallel girders. In computing moments the value of E shall be taken as 3,000,000 lb. per sq. in.

Methods of Analysis

Suggested Procedure in Analysis

Any method of analysis may be used which satisfies the requirements of statics and which is based on the preservation of continuity in the structure; the variations of such methods are nearly unlimited.*

* The following references give fundamental methods.

"Analysis of Continuous Frames by Distributing Fixed-end Moments," Hardy Cross, Trans. A.S.C.E., 1932.

"Continuous Frames of Reinforced Concrete," Hardy Cross and N. D. Morgan, John Wiley & Sons.

"The Modified Slope-Deflection Method," L. T. Evans, Journal A.C.I., October 1931.

"Moments in Restrained and Continuous Beams by the Method of Conjugate Points," Nishkian and Steinman, Trans. A.S.C.E., June 1927.

The energy methods, including the method of least work, will, of course, give the same results. They do not, however, appear to be very convenient in the problems here discussed.

The well-known deformeter-gage method, using the apparatus of Professor George E. Beggs, is described in detail in "The Rigid Frame Bridge"—A. G. Hayden, John Wiley & Sons and elsewhere.

Other references bearing on the methods of analysis follow:

Slope-Deflection

The fundamental method, restricted however to members of constant section, is given in "Analysis of Statically Indeterminate Structures by the Slope-Deflection Method"—Wilson, Richart, and Weiss—Bulletin 108, Engineering Experiment Station, University of Illinois and in several standard texts.

The extension of this method to members of varying section is indicated briefly in "The Column Analogy"—Hardy Cross—Bulletin 215, Engineering Experiment Station, University of Illinois.

Moment Distribution

"Continuity as a Factor in Reinforced Concrete Design," Hardy Cross—Proc. A.C.I., 1929.

"Structural Analysis Based on the Moment Distribution Method of Cross"—T. D. Mylrea—Proc. Eng. Soc. of W. Penna., 1931.

Design of Steel Mill Buildings (Fifth Edition, 1932), Milo S. Ketchum, McGraw-Hill. Chapter XVIII A—Stresses in Stiff Frames by Moment Distribution.

Principles of Reinforced Concrete Construction (Fourth Edition, 1932)—Turneaure and Maurer—John Wiley & Sons.

Structural Theory—Sutherland and Bowman, John Wiley & Sons.

"The Moment Distribution Method of Structural Analysis", G. E. Large and Clyde T. Morris—Bulletin 66, Engineering Experiment Station, Ohio State University.

The following references describing rigid-frame bridges are also of interest.

The Rigid Frame Bridge—Hayden—John Wiley & Sons.

Reports of the Westchester County Park Commission.

"Rigid Frames and Continuous Concrete Spans"—J. W. Baretta—Civil Engineering—September 1932.

Analysis for Live Loads

Where the live load is a series of concentrated loads—trucks, trolley cars, or railway loads—it is convenient to find maxima by the elementary procedure of moving the loads across the bridge and determining the moments produced. An approximate idea of the shape of the influence lines is useful as an aid in spotting the loads, but is not necessary.

In order to avoid repetition of computations, draw first the two influence lines for fixed-end moments in each span. Then distribute unbalanced moments of 100 successively at each support. Now with the loads in any given position, scale the ordinates of the influence lines for fixed-end moments, multiply by the loads and so find the total fixed-end moments, distribute these by use of the factors just determined. The curve of moments for this position of the loads is then easily drawn. The envelopes of all such curves of moments are the curves of maximum moments for the system of loads.

Curves of maximum shears may be got by a similar procedure. Maximum moments and reactions in the piers may also be determined.

Illustration of Computation of Shears and Moments with Concentrated Load Systems. Fig. 1* illustrates the determination of all values of shears and moments in a

* Taken from Continuous Frames of Reinforced Concrete—Cross and Morgan.

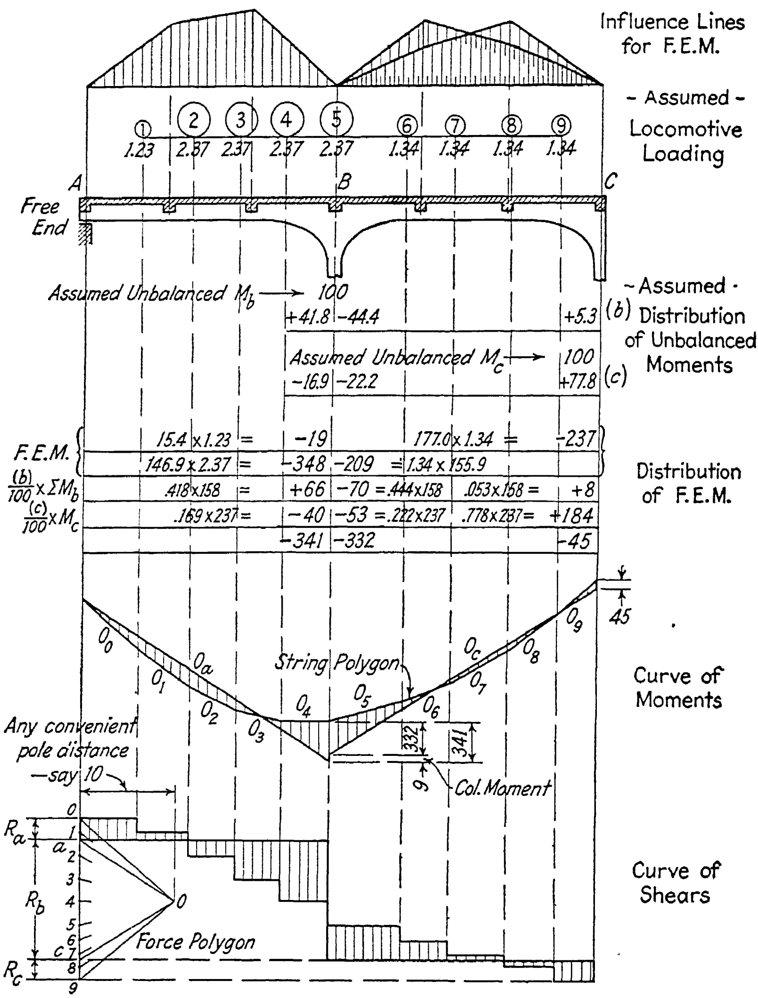

Influence Lines for F.E.M.
- Assumed - Locomotive Loading
1.23
2.37
2.37
2.37
2.37
1.34
1.34
1.34
1.34
A
B
C
Free End
Assumed Unbalanced M_b → 100
+41.8 −44.4
+5.3
(b)
~Assumed · Distribution of Unbalanced Moments
Assumed Unbalanced M_c → 100
−16.9 −22.2
+77.8
(c)
F.E.M.
15.4 x 1.23 = −19
177.0 x 1.34 = −237
146.9 x 2.37 = −348 −209 = 1.34 x 155.9
(b)/100 x ΣM_b
.418 x 158 = +66 −70 = .444 x 158
.053 x 158 = +8
(c)/100 x M_c
.169 x 237 = −40 −53 = .222 x 237
.778 x 237 = +184
−341 −332
−45
Distribution of F.E.M.
45
String Polygon
Curve of Moments
Any convenient pole distance —say 10
332
341
9
Col. Moment
R_a
R_b
R_c
Force Polygon
Curve of Shears

FIG. 1.

frame of two spans for one position of a series of concentrated loads. A series of such values are to be found for successive positions of the locomotive and maxima determined in this way. The outlines of the structures and the loading used are chosen merely to illustrate the method. Note that only one influence line for end moments is used in the span which is simply supported.

The essential steps in the procedure are (a) the influence lines for fixed-end moments, (b) the distribution of unbalanced moments at each joint except the end which is freely supported, (c) the force polygon and string polygon for the loads. These are used over and over for different positions of the loads.

The loads are assumed to be placed on the structure in the position shown. Scale the influence ordinates for fixed-end moments, multiply by the loads and set the totals at the corresponding ends of the girders. Multiply by the distribution factors and find total end moments. Lay off these end moments from the string polygon for the loads and draw the closing lines as shown. This gives at once the complete curve of moments. If we draw, in the force polygon, rays parallel to these closing lines, these rays divide the load polygon into the reactions. We can then project over the end shears and the forces to give the curve of shears on the span.

After the curves of moments and shears are drawn for all positions of the load which are to be considered, the values for maxima may be plotted and the curves of maxima drawn.

If the above procedure is used, the influence lines, if used at all, would be merely sketched as a guide in spotting the loads. If, however, the computer wishes to draw them to scale, he may follow the procedure just explained, drawing curves of moments and shears for successive positions of a unit load and taking from these such values as are wanted in plotting the influence lines.

Curves of moments and shears for dead loads may be computed by the procedure above.

Effect of Temperature Changes, Shrinkage and Movement of Foundations. Compute first the moments which would be produced at the ends of the members by such distortions if the ends were rigidly fixed against rotation. These moments may then be distributed throughout the frame by use of the constants for distributing unbalanced moments found above, just as was done for fixed-end moments produced by loads on the structure.

FORMULAS FOR ELASTIC CONSTANTS.—The elastic constants required in the analysis may be computed by use of the formulas below. Consistent signs for the distances involved must be used throughout. In any member

Let Δ be any short length of the axis, the moment of inertia of the cross-section at this point being I.

x be the distance to this section.

$\bar{x}$ be the distance to the end of the member, subscripts denoting the end under consideration.

These distances are to be measured from the elastic centroid, determined so that

$$\Sigma \frac{\Delta}{I} x = 0$$

End moments due to unit rotation of one end without movement of the other end,

$$\frac{1}{E}\left[\frac{1}{\Sigma \frac{\Delta}{I}} + \frac{\bar{x}_a^2}{\Sigma x^2 \frac{\Delta}{I}}\right] \qquad \text{at the end } A \text{ being rotated}$$

$$\frac{1}{E}\left[\frac{1}{\Sigma\frac{\Delta}{I}}+\frac{x_o\,x_b}{\Sigma x^2\frac{\Delta}{I}}\right]$$ at the end B held fixed

End moment due to unit relative transverse displacement of ends without rotation =

$$\frac{1}{E}\left[\frac{\bar{x}}{\Sigma x^2\frac{\Delta}{I}}\right],$$ $\bar{x}$ being measured to the end under consideration.

Fixed-end moment due to unit concentrated load,

$$\frac{\Sigma(x-e)\frac{\Delta}{I}}{\Sigma\frac{\Delta}{I}}+\frac{\Sigma(x-e)x\frac{\Delta}{I}}{\Sigma x^2\frac{\Delta}{I}}\bar{x}$$

where e is the distance from the elastic centroid to the load, the summations in the numerators to be taken from the load to the end of the member opposite to that under consideration.*

If one end of the member is free, the fixed-end moment at the other end may be computed by first finding the end moments of M_a^1 and M_b^1 at A and at B if both ends are fixed. Then moment at end A fixed when end B is free is

$$M_a^1+\frac{\dfrac{1}{\Sigma\frac{\Delta}{I}}+\dfrac{x_a\,x_b}{\Sigma x^2\frac{\Delta}{I}}}{\dfrac{1}{\Sigma\frac{\Delta}{I}}+\dfrac{x_a^2}{\Sigma x^2\frac{\Delta}{I}}}M_b^1$$

Curves and Tables for Constants—Curves for some of these constants are available for certain assumed cases.

Reference may be made to:
Curves by L. T. Evans in his paper, loc. cit.
Curves by Large and Morris in their bulletin, loc. cit.
Curves by Thor Germundsson, Civil Engineering, October, 1932 (only one of the sets of curves is shown, the full lithographed set being supplied for a small price by the A.S.C.E.)
Continuous Frames of Reinforced Concrete, Hardy Cross and N. D. Morgan, John Wiley & Sons, pages 139–155. (The curves follow those of Evans with additions and modifications.)
See also, "The Column Analogy," Bull. 215, Univ. of Ill., for a general method of computing the constants.
Tables of constants for haunched beams are also to be found in Principles of Reinforced Concrete Construction—Turneaure and Maurer.
Concrete—Plain and Reinforced—Taylor, Thompson and Smulski—Vol. II, John Wiley & Sons.
See also tables of constants for use with the Method of Conjugate Points in discussion by Walter Ruppel of paper by Nishkian and Steinman, loc. cit.

In general the curves and tabulated constants are not "exact" in any general sense, but are correct only for the assumptions on which they are based.

(a) Usually they assume that $I \alpha d^3$. In order to use them in other cases it is necessary to draw an "equivalent haunch" in which $d \alpha \sqrt[3]{I}$ and select the curve which most nearly approximates this haunch. In general this method may be expected to give very satisfactory results.

* This moment, if we use the usual convention of signs for bending moments, is always negative.

(b) They necessarily assume that the haunch shown extends to the center of intersections of the members at the joint. The error from this source is not serious, but it should be recognized.

Note that the same curves may be equally applicable in several methods of analysis. Thus at one end of any straight member

Let S = stiffness

r = carry-over factor

M' = fixed-end moment

M = total moment

M'' = change in moment from fixed-end moment

$\emptyset$ = rotation

Subscripts a or b indicate the end under consideration. Note that $r_a S_a = r_b S_b$ (Reciprocal Relation of Loads and Displacements)

By definition

$$M''_a = S_a\phi_a + r_b S_b \phi_b = S_a(\phi_a + r_a\phi_b) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

This is the fundamental equation of displacements as applied to a straight member. By writing equations $\Sigma M = 0$ ($\Sigma M''_a = \Sigma M'_a$) at each joint, determine values of $\emptyset$ and from these values of M. If the members are of uniform section, this is the method of slope-deflection.

From $M''_a = S_a\phi_a + r_b S_b\phi_b$ and $M''_b = r_a S_a \phi_a + S_b\phi_b$

deduce

$$M''_a - r_b M''_b = \phi_a S_a(1 - r_a r_b)$$

Designate the quantity $S_a(1 - r_a r_b) = S_a{}^1$

Summing at joint A, noting that $\emptyset_a$ is the same for all members,

$$\Sigma M''_a - \Sigma r_b M''_b = \phi_a \Sigma S_a{}^1$$

Then

$$\frac{M''_a - r_b M_b}{S_a{}^1} = \frac{\Sigma(M''_a - r_b M_b}{\Sigma S^1{}_a}$$

Substitute for M''_a and M''_b and rearrange

$$\frac{M_a - r_b M_b}{S_a{}^1} - \frac{\Sigma(\cancel{M_a} - r_b M_b)}{\Sigma S^1{}_a} = \frac{M^1{}_a - r_b M'_b}{S^1{}_a} - \frac{\Sigma(M^1{}_a - r_b M^1{}_b)}{\Sigma S^1{}_a} \quad . \; . \; . \; . \quad (2)$$

which is the general equation of continuity at any joint, subscript a referring to any one member at that joint when not preceded by the summation sign and to all members at that joint when preceded by Σ, and subscript b referring to the other ends of the members meeting at that joint.

The term ΣM_a has been included here for symmetry of form in the equation. It is, of course, equal to zero as indicated by the cancellation.

Equation (2) has, apparently, not been published before. From it the equation of three-moments for beams of constant section not continuous with columns may be deduced as a very special case. It is to be used like the theorem of three moments by writing one such equation for each terminal moment (M_a) and solving the groups of equa-

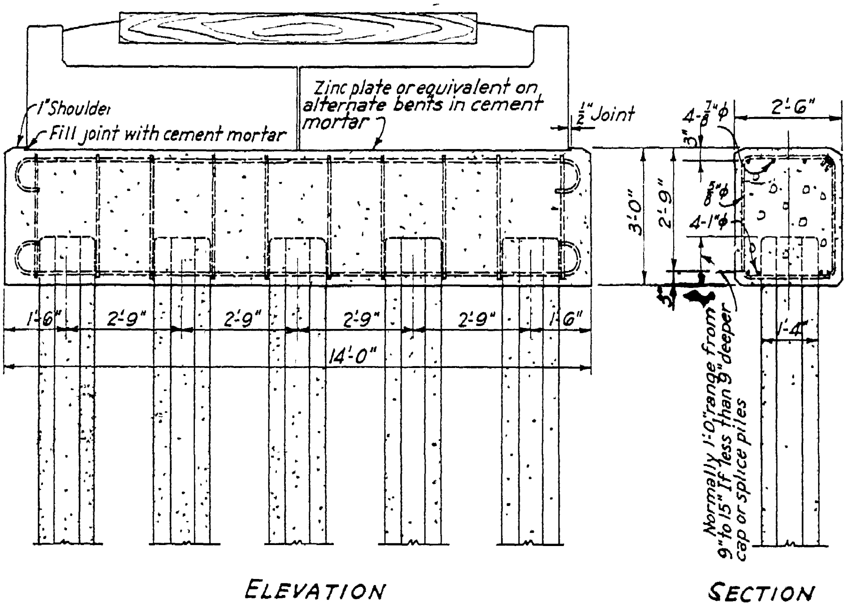
tions simultaneously. The method of moment distribution solves these equations in a special way. The interest of the deduction here is that it indicates how the same constants may be used in different methods of analysis.

Sidesway.—An analysis of a rigid frame is made more easily if there is no linear movement of the joints. For unsymmetrical loading conditions such movement would occur if not restrained, the effect being to relieve the larger critical moments. In the frames here discussed such "sidesway" would usually be resisted by passive pressure of the backfill if the girders are continuous with the abutments and in other cases would not be important. Therefore the structure may be analyzed on the assumption that the joints do not move.

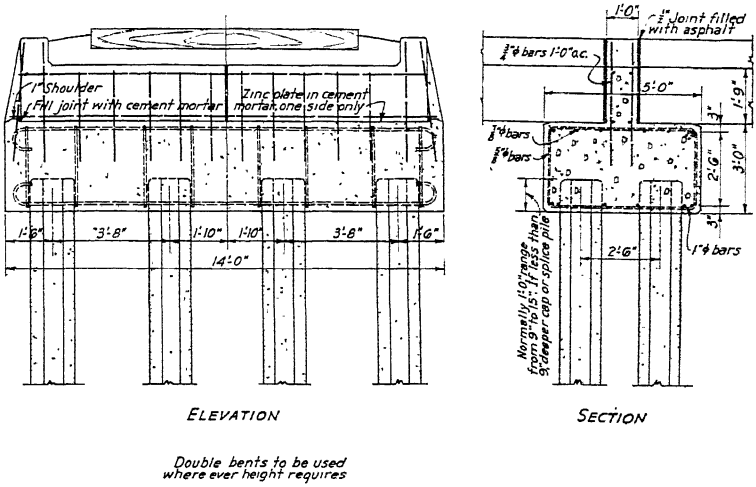
Rib-Shortening.—The formulas given above neglect distortions due to shear and to longitudinal forces. In arches it is customary to correct for the effect of the longitudinal forces. In the type of structure here referred to a correction may be made in much the same way as in arches, but the effect is small and is easily masked by the uncertainties involved in the linear distortions arising from other causes.

Section B

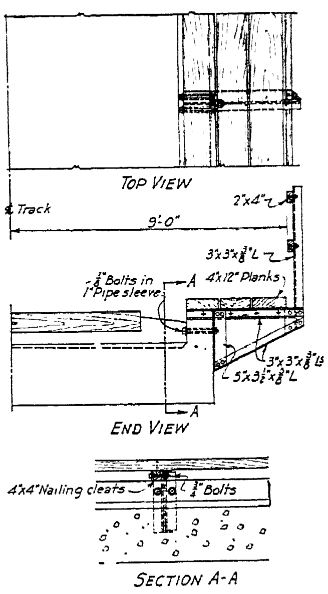
BALLASTED DECK REINFORCED CONCRETE TRESTLE



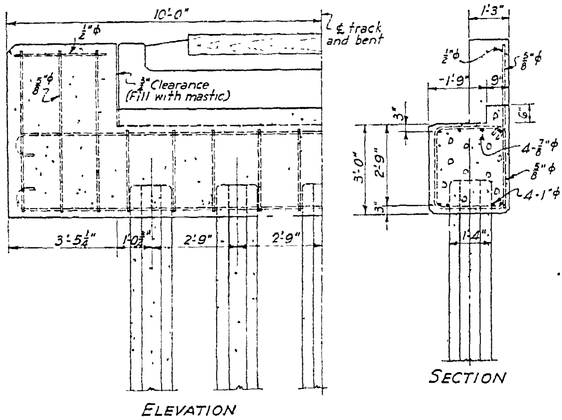
Design for Single Bent, Reinforced Concrete Trestle.



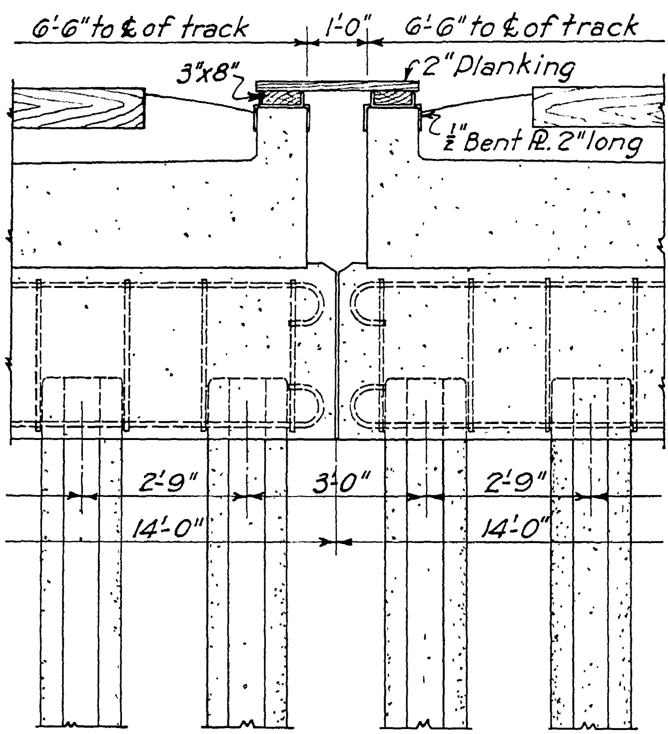
DESIGN FOR DOUBLE BENT, REINFORCED CONCRETE TRESTLE.



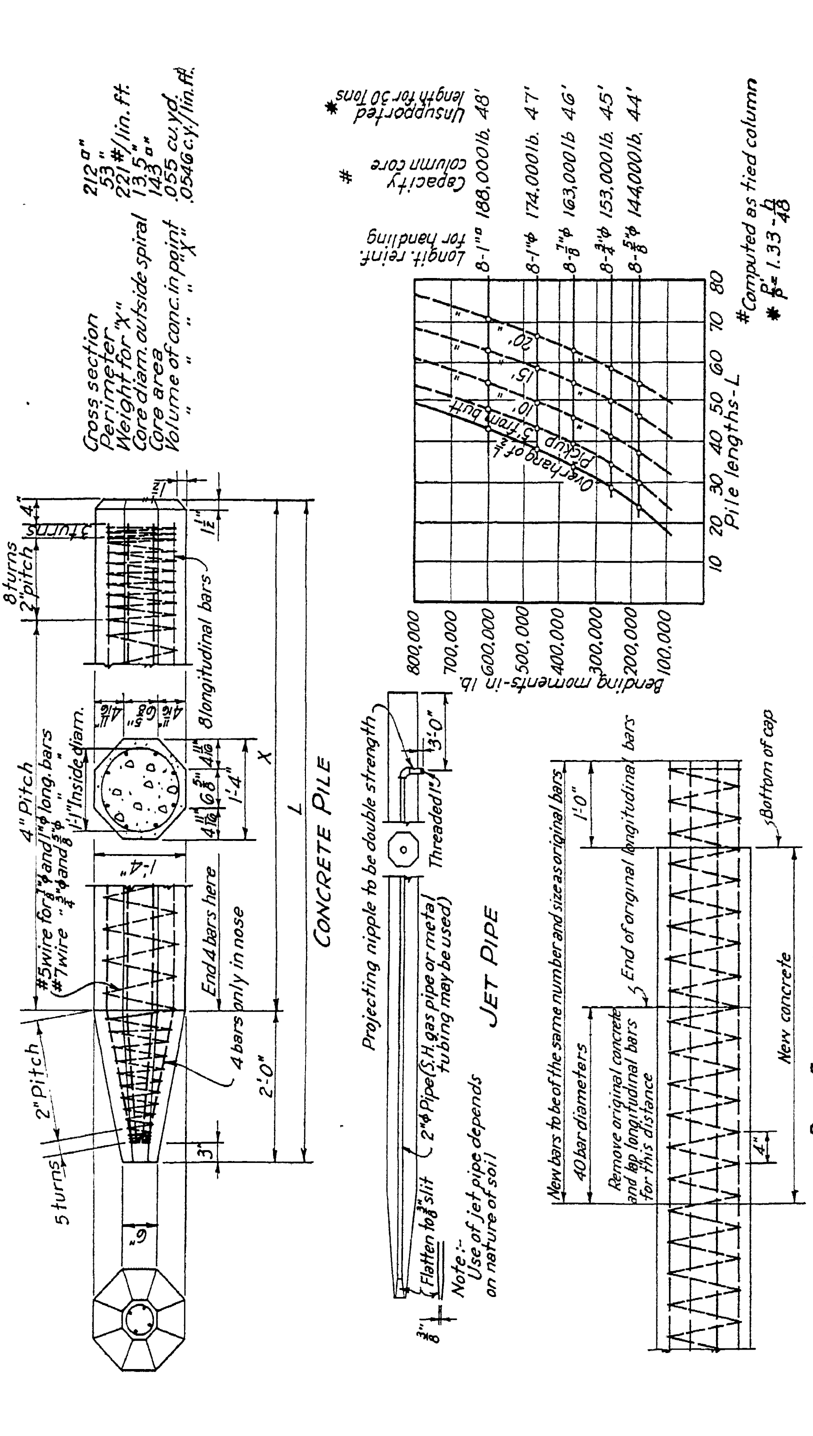
DESIGN FOR TRAINMEN'S WALK,
REINFORCED CONCRETE TRESTLE.



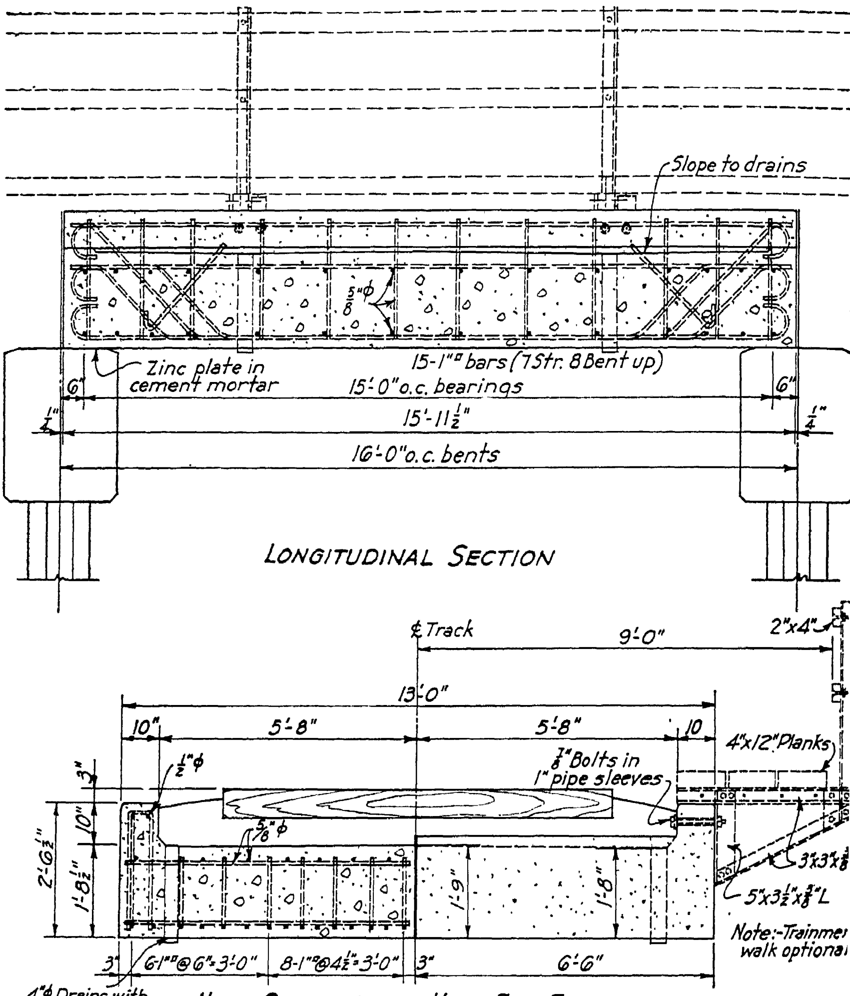
DESIGN FOR ABUTMENT BENT, REINFORCED CONCRETE TRESTLE.



ELEVATION AT BENTS
MULTIPLE TRACK



Design of Piles, Reinforced Concrete Trestle.



General notes:-
Designed in accordance with specifications for Portland Cement concrete, plain and reinforced of the A.R.E.A. (Manual 1929)
Class of concrete-3500.
Grade of reinforcing steel - Intermediate.
Live load - Coopers E 60.
Impact - 50 % added to weight on drivers for slabs and 25% for piles.
Handling stresses - Top bars in slabs for handling with stirrups and for center blocking. Reinforcement in piles varies with length and method of handling.
Axial load on piles = 30 Ton.

DESIGN FOR SLAB, REINFORCED CONCRETE TRESTLE.

Appendix C

(3) PROGRESS IN THE SCIENCE AND ART OF CONCRETE MANUFACTURE

L. W. Walter, Chairman, Sub-Committee; J. T. Andrews, M. C. Blanchard, L. V. Haegert, A. D. Harvey, W. K. Hatt, A. C. Irwin, O. V. Parsons, D. B. Rush, C. A. Whipple, D. E. Woozley, W. K. Wyatt, J. J. Yates.

CURING

When neat Portland cement is mixed with only enough water to form a plastic paste, we may visualize the grains of various sizes separated by a thin film of water. Increasing the amount of water slightly, simply increases the thickness of the water film and by continuing to increase the water a layer of water will appear on top of the saturated paste. After the introduction of the water, hydration products are formed on the surface of the grains and occupy space formerly occupied by the water. Continuance of the formation of these hydration products results in connecting the grains at first by thin walls or columns which, as hydration proceeds, grow in strength and occupy more and more space formerly taken up by the water films. The conditions recognized as "initial set" and "final set" are simply arbitrarily selected stages in a continuing process. It is evident that the larger and stronger the connecting walls become, the smaller will be the unfilled spaces between the grains and the greater will be the watertightness of the mass and its resistance to external forces. Continuation of this process of hydration to the condition of watertightness and great strength is the primary purpose of curing.

In a practical sense proper curing is that control of moisture and temperature conditions surrounding the concrete after placement, that prevents or minimizes evaporation of contained mixing water and secures and maintains a favorable temperature throughout the curing period. The effectiveness of all methods of curing may be judged on the basis of this definition.

The effect of curing on the strength and absorption of concrete has been shown in previous reports (Vol. 20, Proceedings, 1919, and Vol. 22, Proceedings, 1921). It is there indicated that as long as proper curing is continued, the strength and resistance to wear of the concrete increases. Later research has amply confirmed these conclusions. The reports of this Committee for 1930 also give some data showing that proper curing reduces the absorption as well as the permeability of concrete.

Some of the results of comprehensive tests on permeability now available are shown in Fig. 2.

The test specimens were, in general, discs of concrete two inches thick by six inches in diameter and included various water ratios and periods of curing. The maximum size of aggregate was ¾ inch and the discs were subjected to 80 pounds water pressure per square inch throughout the period of test. Details of the testing apparatus are shown by Fig. 1. All specimens were surface dry at the beginning of the test. Before testing, the surfaces were ground to a depth of about $\frac{1}{16}$ inch to ⅛ inch. They were removed from the molds from 20 to 24 hours after being made and were cured in a moist room at 70° Fahr. and relative humidity of 100 per cent until insertion into the testing apparatus.

The curves show that the permeability decreases with the length of time of moist curing for all of the water ratios and their corresponding mixes. The 9-gallon and the 8¼-gallon mixes did not become entirely watertight even after 28 days moist curing. However, the 7¼-gallon mixes were practically watertight as measured by leakage after 28 days and the 6-gallon mixes were watertight in 7 days. A feature of these tests was

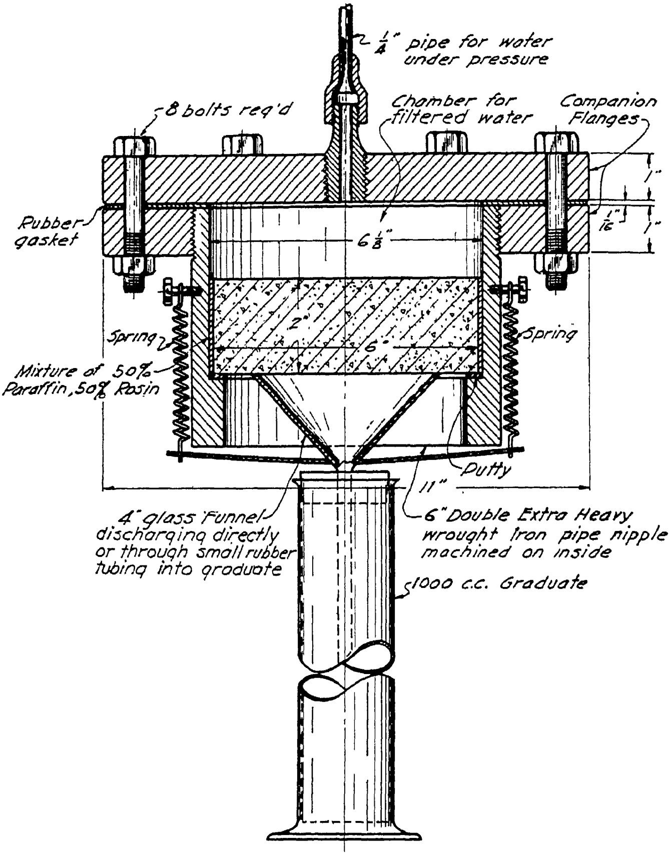


FIG. 1—Apparatus for Measuring Permeability of Concrete.

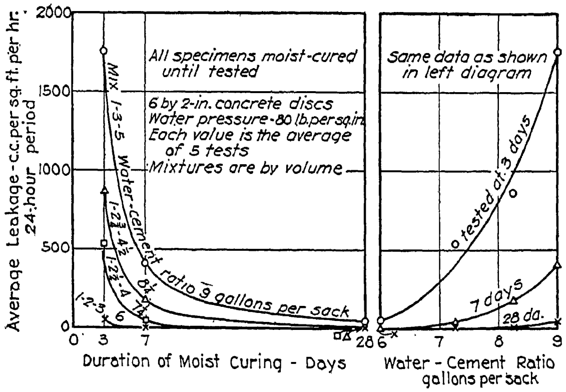


FIG. 2—Effect of Continued Moist Curing.

the fact that specimens in the testing apparatus showed positive evidence of curing with about the same rate of decrease in permeability as those cured in the moist room for a like period. In other words, the curing process continued while the discs were under pressure and water was passing through them. It is also interesting to note that specimens of 6-gallon mixes, when tested after 28 days moist curing, showed no leakage under 250 pounds per square inch pressure for 30 minutes. After 9 days moist curing there was only a trace of leakage.

The practical significance of this curing effect of water must be judged on the assumption that other factors cannot be ignored. Even proper curing cannot be expected to seal up laitance seams, honeycombed sections or sizeable cracks or other defects.

Methods of Curing

The relative merit of various methods of curing is still a matter of dispute, but a majority of investigators agree that continuous moist curing, under temperature control, is the preferable method and a most dependable one.

1. Steam Curing

(a) High Pressure.—Since the hardening process is greatly accelerated by heat, "steam curing" has been employed as a means to obtain early use of concrete. It is obvious that temperature and pressure control are inseparable from proper curing. In many instances the strength of concrete has been seriously impaired by too much emphasis on the temperature obtainable in steam curing and not enough to the vital requirement of moisture. Both air and water expand with an increase in temperature, and water vapor may exert noticeable pressure at temperatures considerably below the boiling point. Superheated steam in a no pressure curing chamber may raise the temperature of the concrete to or above the boiling point of water with consequent vaporization of the contained water and expansion of the contained air. This internal pressure would most certainly be harmful to the green concrete, and in addition on withdrawal of such treatment, without any other moist curing, the units would tend to dry out rapidly with consequent loss of strength and durability. However, if the curing chamber is closed and capable of taking pressure so that the units of concrete will be under equal pressure from all sides, the curing process may be greatly accelerated without injury to the concrete. This is known as "high pressure steam curing".

(b) Low Pressure Curing.—The term "low pressure steam curing" is applied to the method in which steam is used to supply heat either in pipes or in the air of the curing chamber but without appreciable pressure within the chamber and with an adequate supply of moisture. The temperature should not exceed 125° Fahr. In general, the air surrounding the concrete should be supersaturated.

The use of salamanders or dry steam pipes that merely heat the air in an enclosure and thus produce rapid evaporation of moisture from the surface of the concrete cannot be too strongly condemned. Adequate moisture must be present.

2. Chemical Applications

(a) Calcium Chloride.—Flake calcium chloride spread upon the surface of concrete pavements for curing is approved by the Highway Departments of some states. Its value is still a matter of research. Results of investigations show some disagreement and particularly when laboratory data is compared with field data. About 2½ pounds of calcium chloride per square yard of surface is the amount usually specified.

Deliquescence of calcium chloride takes place very slowly when relative humidity is less than 40 per cent or temperature is in excess of 90° Fahr. Surface applications of calcium chloride are therefore not effective under climatic conditions of low relative humidity and high temperature.

Rough averages of test data indicate the effectiveness of such curing as between 80 per cent and 100 per cent of that obtained with wet earth or burlap.

Calcium chloride used integrally should be considered only as an aid to curing. It accelerates the early hardening of concrete and thus reduces the curing time necessary to obtain a given strength. Table I shows that specimens in which calcium chloride was used as an admixture and without other provision for curing were lower in strength than those without admixture that were moist cured for 7 days.

(b) Sodium Silicate.—Tests indicate that sodium silicate used as a surface application for curing has, apparently, little value.

3. Coatings

(a) Paint Coatings.—These include paint or spray coats intended to prevent evaporation of contained moisture from the surface of the concrete. When such coatings are exposed to the sun's rays, and are black in color there results an increase in the temperature and therefore in the volume change of the concrete, at early periods. This objection may be largely overcome by applying a coat of light paint to the black surface or by dusting on some light colored material. Paint coatings of paraffin or linseed oil have considerable value as curing methods.

(b) Waterproof Paper.—The use of waterproof papers that completely cover the surface are of value in proportion to their effectiveness in preventing evaporation from the surface of concrete that is moist at the time of application.

Table I shows relative values of different curing methods abstracted and rearranged from data published in the Journal of the American Concrete Institute*. These data are more favorable to the paint coatings and coverings than would be expected in the field for the reasons that after the moist room curing the uncovered specimens were subjected to the dry air of a laboratory, and received no advantage from rains or high humidity air. The specimens with paint coatings and coverings were stored under more nearly ideal conditions since they were not subject to abrasion nor to weather damage. The results, therefore, for periods longer than those of moist curing of the uncoated specimens greatly favor the coated specimens.

Conclusions

1. Proper curing is one of the most important single factors in obtaining the desirable qualities of concrete.

2. The relative value of any method of curing depends upon its effectiveness in controlling temperature and preventing loss of water from the mass during the curing period. Continuous moist curing with temperature control is a preferred method.

3. Surface coatings that prevent loss of moisture are in general effective. Black coatings that absorb the sun's rays should preferably be covered with white material.

4. Proper curing is essential to develop impermeability of concrete made by ordinary methods. Tests indicate that concrete of a workable consistency made with six gallons or less of water per sack of cement and placed without segregation will be watertight after 7 days of moist curing at 70° Fahr.

* Study of Methods of Curing Concrete, by H. F. Gonnerman, Journal of American Concrete Institute, February 1930.

*TABLE I—RELATIVE VALUE OF DIFFERENT METHODS OF CURING

Age	*No Admix. Mold 1 da. Moist 6 da. Air of lab.*	*2% $CaCl_2$ Mold 1 da. Air of lab.*	*Black Paint Coatings (a)*	*(b)*	*(c)*	*Linseed Oil Coating*	*Paraffin Coating*	*Sodium Silicate Coating*	*No Admix. Mold 1 da. Moist 13 da. Air of lab.*	*No Admix. Mold 1 da. Moist until Test, Test damp.*
1 da.	....	1220	....	....	....	....	....	....	....	740
3 da.	....	2220	1990	....	....	....	1820	1740	....	1860
7 da.	2990	2860	3060	3180	....	2760	2920	2570	....	2910
14 da.	3640	3140	4110	....	....	....	3830	3020	4120	3770
28 da.	4260	3280	4880	5040	4220	4410	4380	3240	4590	4870
3 mo.	4130	3260	4660	4950	4460	4560	4460	3140	4980	5830
1 yr.	4390	3570	5140	5460	4780	5140	4300	3640	4720	7220

* Abstracted from Journal of the American Concrete Institute, Vol. I, No. 4, Feb., 1930; "Study of Methods of Curing Concrete", by H. F. Gonnerman.

Appendix D

(8) SPECIFICATIONS FOR REPAIRING DETERIORATING CONCRETE

A. C. Irwin, Chairman, Sub-Committee; G. E. Boyd, Kennerly Bryan, Jr., W. F. Cummings, Maurice Coburn, G. F. Eberly, L. V. Haegert, W. K. Hatt, J. A. Lahmer, C. P. Richardson, D. A. Ruhl, G. L. Staley, G. E. Tebbetts, H. H. Temple.

1. Scope

These specifications apply to repairs to concrete made necessary or advisable by causes other than foundation failure or overload. They apply to patching, restoration and encasement of a structure or part of a structure.

Engineering plans should be made when strengthening of the structure is involved.

2. General

Conditions causing or contributing to deterioration, including faulty drainage, shall be corrected where practicable. If impracticable to correct inadequate drainage and thus prevent saturation of the concrete where it will be exposed to freezing and thawing, the part of the structure so exposed shall be made water-tight by replacing honeycombed and unusually porous portions and/or by densification and filling of cracks by methods satisfactory to the Engineer.

Watertight surface coatings will not be accepted unless protected so that water may not collect behind them and freeze.

Loose and deteriorated concrete shall be removed to a sufficient depth to expose sound concrete for a bonding surface.

Thin or feathered edges shall be avoided and the boundaries of the area to be restored shall be cut square or undercut preferably to a depth of not less than 1 inch.

Abrupt changes in the thickness of concrete patches or encasement shall be avoided.

3. Materials

The materials used shall conform in physical properties to the Specifications for Portland Cement Concrete, Plain and Reinforced, of the American Railway Engineering Association.

The color of the aggregate and cement for patching or partial encasement shall be selected to produce a color as nearly the same as practicable as that of the old concrete.

4. Water Ratio and Consistency

The water-cement ratio of the new concrete shall not exceed 6 gallons per sack of cement. A lower water-cement ratio shall be used if practicable.

The consistency of the concrete shall be such as to permit of maximum compaction.

5. Reinforcement

Reinforcement shall consist of mesh and/or bars and where dowels or anchor bolts are used it shall be securely fastened to them.

The sectional area of steel reinforcement where used shall be not less than 3/10 of 1 per cent of the average sectional area of the new concrete. Where the work extends around corners, the reinforcement shall be not less than 6/10 per cent of the section of the concrete at the corner. Laps at corners shall be carried far enough along the adjoining faces to develop by bond in each face the full strength of the reinforcement or positive mechanical anchorage provided that will make the reinforcement continuous without loss of tensile strength.

Reinforcement in the old structure that is to be included in the repair work shall be thoroughly cleaned and any important reduction in area shall be supplied with additional reinforcement. All reinforcement involved in the repair work shall be completely embedded in new concrete and shall be not less than one inch from the surface of concrete that will be subjected to severe exposure.

6. Anchorage

Dowels and expansion bolts shall be set after the bonding surface is exposed. Any space in the old concrete around dowels or anchor bolts shall be filled with cement mortar rammed into place or by grouting. The concrete surrounding dowel holes shall be kept thoroughly wet for a period of at least one hour prior to packing or grouting. Anchors so packed shall be set at least two days prior to attachment of reinforcement to them or to placement of concrete, and shall not be disturbed during that time.

(a) Attachment of Reinforcement. Dowels, approved expansion bolts, or other anchorage shall be used where necessary to hold the reinforcement in place.

(b) Provision for Bond. Where it is impracticable to secure a good natural bond between the new and old concrete or where tension or shear at the bonding surface will be a principal stress, the integrity of the action of the new concrete with the old shall be assured by dowels and/or expansion bolts of sufficient size, number and embedment to develop the strength of the new concrete in combination with its reinforcement, if any.

7. Preparation of Bonding Surface

(a) The bonding surface shall be rough and clean. Loose particles, dust and dirt shall be removed by vigorous brushing with wire brushes, sand blasting or otherwise, prior to application of new material. Oil or film of any sort that may reduce the bond of the new material to the old concrete will not be permitted.

(b) The bonding surface shall be maintained constantly wet for a minimum of one hour prior to application of new material. After the wetting period sufficient time shall be allowed to elapse, or special means used, to remove all surface wetness and to produce a damp surface that is slightly absorptive. The fresh material shall be applied when this condition is attained. In no case shall fresh material be applied to a dry surface.

8. Application of New Concrete

(a) Bonding Coat (Hand Work). The first or bonding coat shall be composed of one part cement to one part of sand. The mortar for bonding coats shall be of plastering consistency and shall have been mixed from one-half to three hours (depending on temperature and humidity) prior to using, but shall be plastic at the time of application. Water shall not be added to retemper the bonding coat mortar. The bonding coat shall be applied to a thickness of approximately ¼ inch immediately prior to placement of the body of the new concrete. It shall be projected or splattered against the prepared surface with force and shall not be troweled, screened, or disturbed until the next layer of new concrete is applied.

(b) Built-up Patch—Overhead, Vertical or Steep Surface. Successive layers of concrete shall be applied if practicable while the preceding one, including the bonding coat, is still plastic, and until the requisite amount of concrete is applied. If necessary to prevent sloughing of an already applied layer, it may be allowed to harden in place until it has acquired sufficient strength to hold the next layer, but in this event the next layer shall be applied as for a bonding coat. The cavity may be overfilled and brought to approximate surface by hammering or pushing on a board in contact with, and extending beyond the patch. Excess concrete shall be carefully removed with a sharp tool and the patch brought to the required surface by patting with a wood float or trowel. Heavy troweling or working of the finished surface will not be permitted, until the con-

crete has acquired sufficient stiffness to prevent disturbance of its original position below the surface troweled. All troweling and/or floating of the plastic surface shall be lightly done so as to limit its effect as far as possible to the surface.

(c) Built-up Patch—Horizontal Top Surface. After the bonding coat, the concrete shall be rammed into place until the cavity is overfilled. The patch shall then be further consolidated by hammering on a board in contact with but extending beyond the patch. This shall be repeated prior to initial set of the cement. Excess concrete shall be carefully removed with a sharp tool so as not to drag the surface and the final finishing accomplished by patting and light troweling.

(d) Packing in Forms. Where restoration or encasement is accomplished by ramming the new concrete in between forms and the old surface, the forms shall have sufficient strength to withstand the pressure of the new concrete without yielding appreciably. If possible, the new concrete shall be placed in layers, each rammed solidly into place while the preceding layer is plastic. In any case the new concrete shall completely fill the space provided and present a surface identical in location with the original. Vibration of the forms in lieu of ramming is subject to approval of the Engineer. Vibrators shall preferably deliver not less than 3000 impulses per minute.

8a. Cement Gun Work. Cement gun concrete shall be a mixture of one part Portland cement and approximately three parts sand free from particles ¼ inch size and over. The amount of sand shall be based on dry, loose measurement but shall have not more than 8 per cent by weight of moisture when mixed with the cement. The sand and cement shall be thoroughly mixed before being put into the hopper of the cement gun.

The air pressure in the cement gun shall be maintained uniform and not less than 35 pounds per square inch, while placing the mixed material. This pressure shall be increased for horizontal delivery distances exceeding 100 feet and for vertical distances exceeding 25 feet. The water pressure shall be not less than 25 pounds per square inch more than the air pressure. The nozzle of the gun shall be directed as nearly as possible at right angles to, and shall be held at 2 feet to 4 feet from the working surface.

A sufficient number of coats shall be applied to obtain the required thickness but not less than two coats shall be placed. The thickness of each coat shall be such that it will neither slough nor decrease the bond with the preceding coat. At least two hours shall elapse between the placement of succeeding coats.

Shooting strips shall be used to obtain true lines, corners and surfaces, but the final or flash coat shall not be troweled or worked in any manner.

9. Curing and Protection

The surface of all new concrete shall be kept from becoming dry for a period of at least seven days beginning immediately after placement except where high early strength concrete is used in which case the curing period may be shortened as determined by the Engineer to that which will produce equivalent strength.

Repair work shall not be done in freezing weather unless properly protected nor until the old structure is free from frost. The new concrete shall have a temperature when placed of not less than 50 deg. Fahr., nor more than 120 deg. Fahr., and shall be kept at a temperature not lower than 50 deg. Fahr., for not less than 72 hours after placing, or until the concrete has thoroughly hardened.

10. Encasement

Where the repair work consists of encasement definite provision satisfactory to the Engineer shall be made at the time the work is being done, for the prevention of subsequent entrance of water between the old and the encasing concrete, particularly where it will be subject to alternate freezing and thawing temperatures.

Appendix E

(9) DESIGN OF EXPANSION JOINTS INVOLVING MASONRY STRUCTURES

C. A. Whipple, Chairman, Sub-Committee; G. E. Boyd, Theo. Doll, L. V. Haegert, A. D. Harvey, J. A. Lahmer, C. P. Richardson, C. A. Ruhl, C. P. Schantz, A. W. Smith, L. W. Walter.

Your Committee has collected from a number of carriers plans covering various types of expansion joints involving masonry structures to meet various conditions, and submits sketches (Fig. 1 to 21) covering these types.

It is recommended that these be received as information and the subject re-assigned for further study.

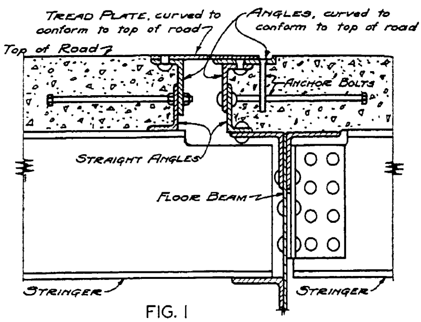


FIG. I

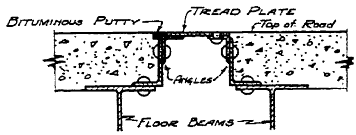


FIG 2

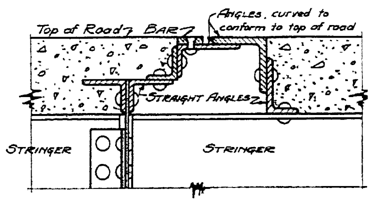


FIG. 3

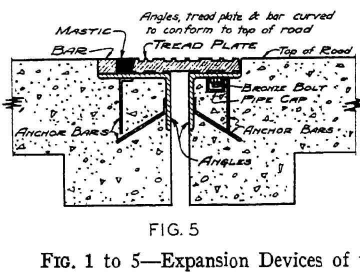


FIG. 5

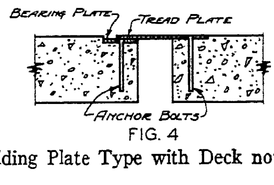


FIG. 4

Fig. 1 to 5—Expansion Devices of the Sliding Plate Type with Deck not Waterproofed.

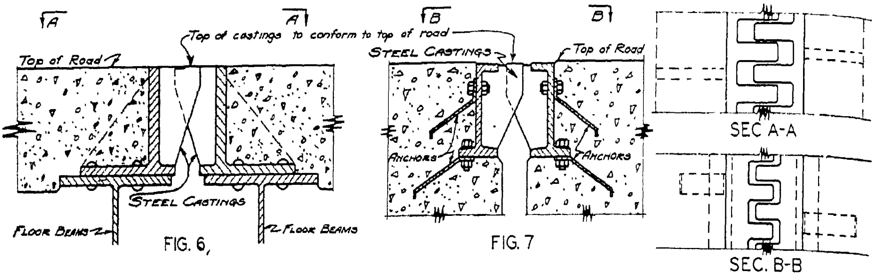


Fig. 6 and 7—Expansion Devices of Interlaced Castings—Deck not Waterproofed.

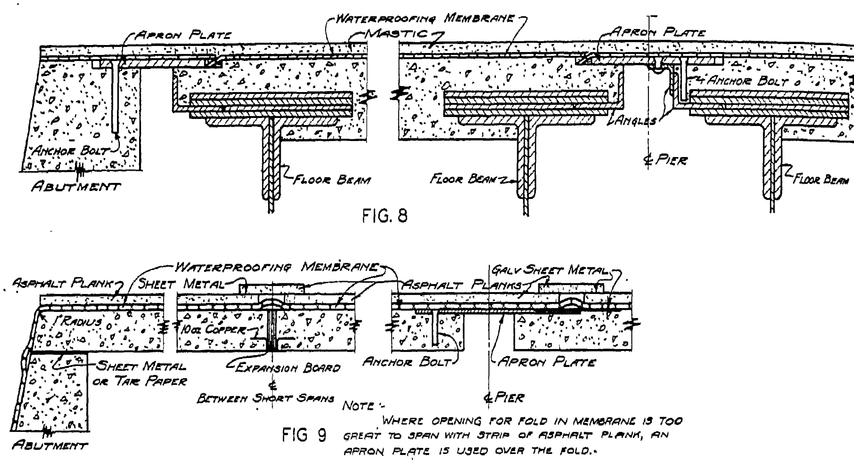


Fig. 8 and 9—Expansion Devices for Waterproofed Railway Bridge Decks on Steel Spans.

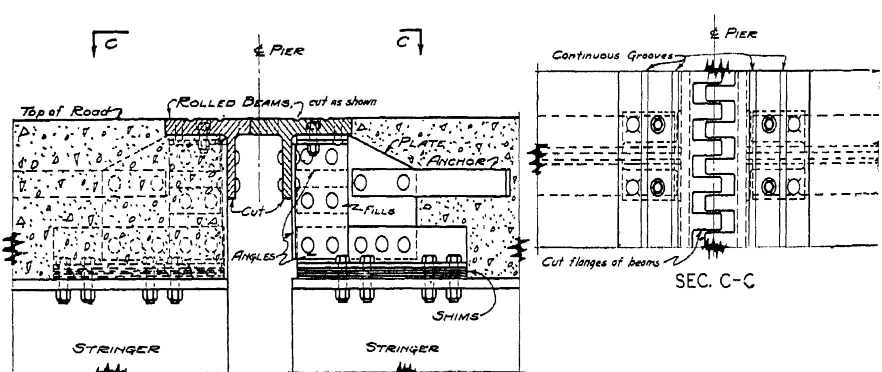


Fig. 10—Expansion Device of Heavy Wide-Flanged Beams, Flame-Cut and Interlaced Deck not Waterproofed.

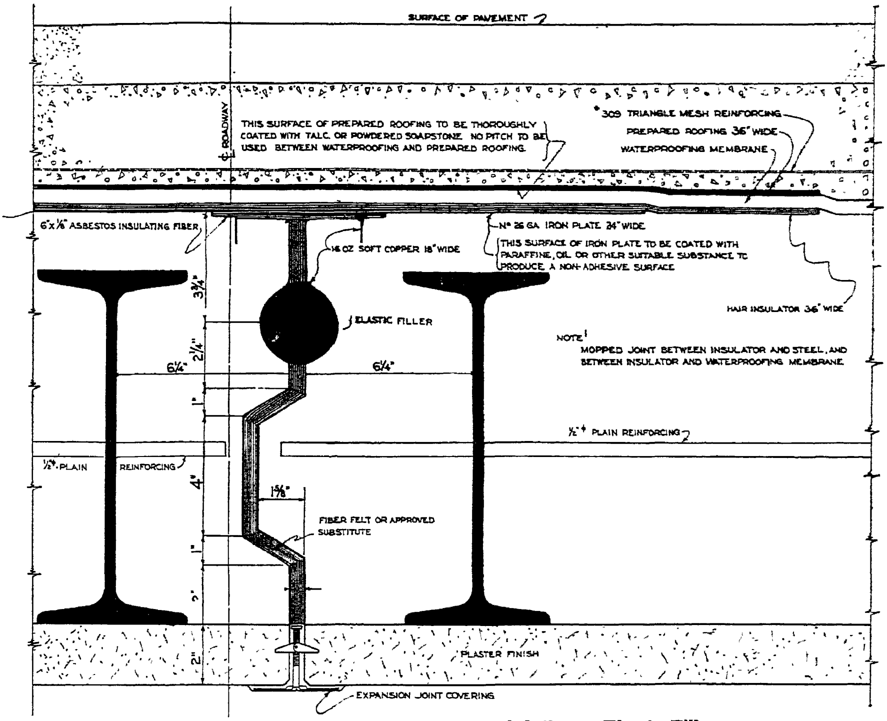


FIG. 11—Expansion Device Waterproofed Type—Elastic Filler.

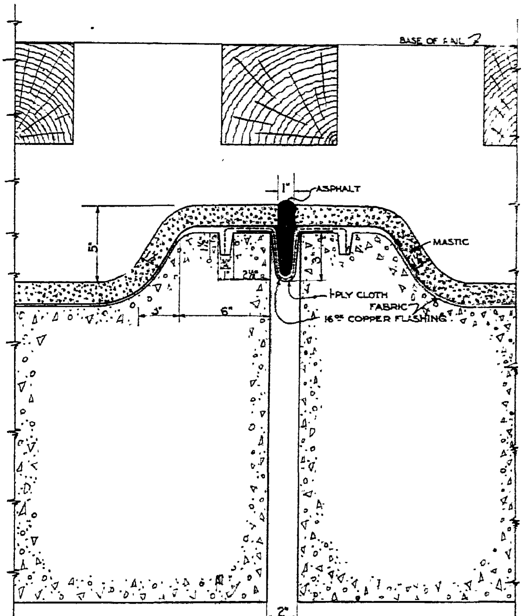


FIG. 12—Expansion Joint Device—Elastic Filler.

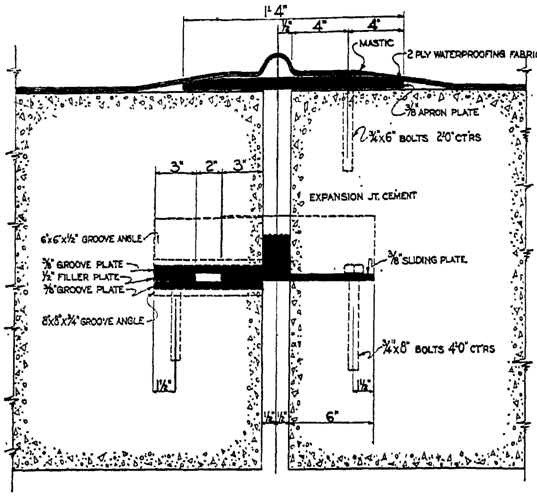


Fig. 13—Expansion Joint Device Deck Waterproofed—Sliding Plate.

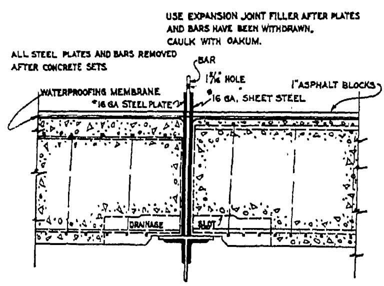


Fig. 14—Expansion Joint Device—Encased I-Beam Floor.

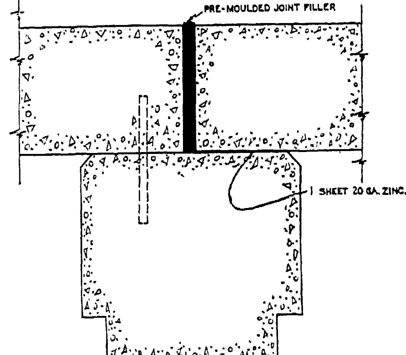


Fig. 15—Expansion Joint Device—Slab Type Thick Floor.

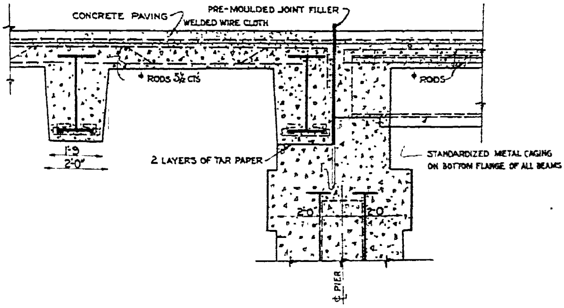


Fig. 16—Expansion Joint Device—Elastic Filler.

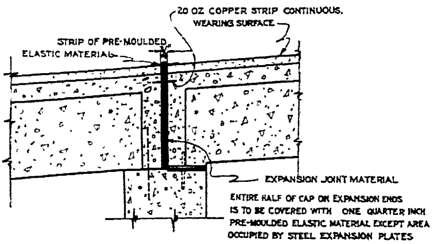


Fig. 17—Expansion Joint Device—Elastic Filler.

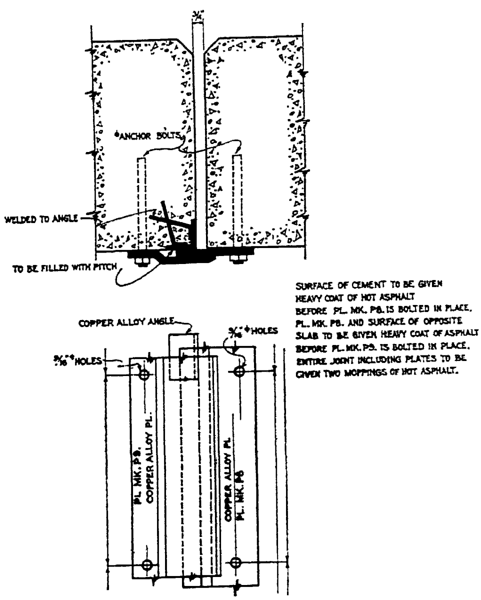


Fig. 18—Expansion Joint Device—Slab Type Thick Floor.

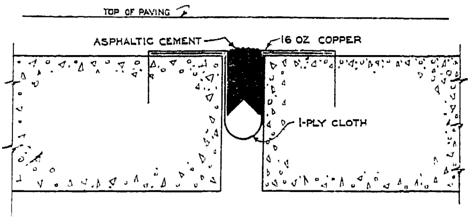


FIG. 19—Expansion Joint Device—Slab Type Thick Floor.

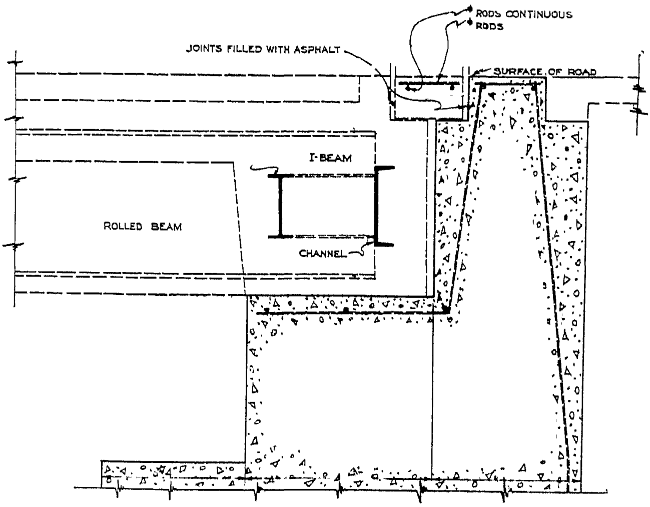


FIG. 20—Expansion Joint Device at Abutment.

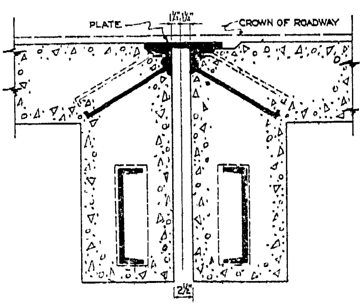


FIG. 21—Expansion Joint Device—Not Waterproofed.

REPORT OF COMMITTEE IV—RAIL

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W. J. BACKES,
J. B. BAKER,
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J. G. WISHART,
L. YAGER,
J. B. YOUNG,
Committee.

* Died November 11, 1932.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report covering the following assignments:

(1) Revision of Manual (Appendix A).

(2) Details of Mill Practice and Manufacture as they affect Rail Quality and Rail Failures, giving special attention to Transverse Fissure Failures, collaborating with the Rail Manufacturers' Technical Committee (Appendix B).

(3) Compilation of Statistics of all Rail Failures, making special study of Transverse Fissure Failures (Appendices C-1, C-2, C-3).

(4) Cause and Prevention of Rail Battering, collaborating with Committee V—Track (Appendix D).

(5) Economic Value of Different Sizes of Rail (Appendix E).

(6) Revision or Elimination of Specifications for Spring Washers, collaborating with Committee V—Track (Appendix F).

(7) Compilation of Information of Alloy and of Heat-Treated Carbon Steel Rails, addressing the various Railways for Records of such Tests as they may have (Appendix G).

(8) Preparation of Specifications for Intermediate Manganese Steel Rail (Appendix G).

(9) Relative merits of Rail Sections heavier than 100 lb. per yard from the Standpoint of Economical Distribution of Metal and Strength (Appendix F).

(10) Application of Upset Joint Bars on all Rail badly worn on fishing surfaces (Appendix D).

(11) Rail Lengths in Excess of Thirty-Nine Feet (Appendix F-3).

Action Recommended

1. That revisions of the "Standard Specifications for Open-Hearth Carbon Steel Rails—1925" recommended in Appendix A be approved for publication in the Manual as recommended practice.

2. That the "Specifications for Spring Washers—1933," recommended in Appendix F-1, be approved for publication in the Manual as recommended practice.

3. That the 131 lb. rail section recommended in Appendix F-2, be approved for publication in the manual as recommended practice.

Bulletin 353, January, 1933.

4. That the present 120, 130, 140 and 150 lb. R.E. standard rail sections be withdrawn from the Manual as recommended in Appendix F-2.

5. That the drilling of rails appearing on page 162 of the Manual be revised as recommended in Appendix F-2, and published in the Manual as recommended practice.

6. That reports on subjects 2, 3, 4, 5, 7, 8, 10 and 11 be received as information.

Respectfully submitted,

THE COMMITTEE ON RAIL,
EARL STIMSON, *Chairman*.

Appendix A

(1) REVISION OF MANUAL

A. F. Blaess, Chairman, Sub-Committee; W. C. Barnes, N. J. Boughton, C. B. Bronson, E. E. Chapman, W. A. Duff, L. C. Fritch, F. M. Graham, C. R. Harding, A. W. Newton, G. J. Ray, C. P. VanGundy, W. P. Wiltsee, J. B. Young.

REDUCTION OF THE CARBON CONTENT AND ADJUSTMENT OF MANGANESE CONTENT IN THE RAIL SPECIFICATIONS

The upper limits of carbon in the present specifications for 100 to 140-lb. rail were fixed on the basis of experience with lighter weight rail. Records of the heavier rail in service have indicated that they may be too high and several months ago the Manufacturers Technical Committee suggested that consideration be given to lowering the upper limits of carbon and adjusting the manganese contents. Such consideration has been given by your Committee and recommendation is made for reducing the upper limits of carbon, restricting its range to 13 points, and increasing the manganese as shown in Table II of this report.

CHANGE IN SILICON CONTENT

The present specifications stipulate a minimum of 0.15 silicon without restriction as to maximum. A tendency has been noted on some roads towards an increase in the number of failures of rail high in this element. To overcome this it is proposed to specify a range in silicon from a minimum of 0.10 to a maximum of 0.23.

For the purpose of comparison the present chemical requirements as given on page 148 in the Manual are shown in Table I below. Proposed chemical requirements recommended by the Committee are shown in Table II.

TABLE I—PRESENT CHEMICAL REQUIREMENTS

Constituents	Weight in lb. per yard			
	70—84	85—100	101—120	121—140
Carbon	0.53—0.70	0.62—0.77	0.67—0.83	0.72—0.89
Manganese	0.60—0.90	0.60—0.90	0.50—0.90	0.50—0.90
Phosphorus, not to exceed	0.04	0.04	0.04	0.04
Silicon, minimum	0.15	0.15	0.15	0.15

TABLE II—PROPOSED CHEMICAL REQUIREMENTS

Constituents	Weight in lb. per yard.			
	70—84	85—100	101—120	121—140
Carbon	0.53—0.70	0.64—0.77	0.67—0.80	0.69—0.82
Manganese	0.60—0.90	0.60—0.90	0.70—1.00	0.70—1.00
Phosphorus, not to exceed	0.04	0.04	0.04	0.04
Silicon	0.10—0.23	0.10—0.23	0.10—0.23	0.10—0.23

CLASSIFICATION MARKINGS

Acting upon the report of several members that the requirement in paragraph 17, sub-paragraph (e) of rail specifications, that "all rails of a heat whose carbon content exceeds the mean carbon percentage of the specified range shall have both ends painted blue", has resulted in giving a wider carbon range than desirable for rails for use under conditions contemplated by the specifications.

It is the recommendation of the Committee that sub-paragraph (e) be changed to read:

> "All rails of a heat whose carbon content is in the upper five points of the carbon percentage of the specified range shall have both ends painted blue."

BRANDING AND STAMPING

In 1931 and 1932 the Association adopted recommendations for branding and stamping rails. It is the thought of the Committee that these recommendations should be incorporated in the rail specifications as indicated under "Proposed Paragraph 16".

Present Paragraph 16

Branding

16. Brands made so plain and sharp that they may be read as long as the rails are in service shall be rolled on or hot stamped into the side of the web of each rail in accordance with the following requirements and to indicate:

(a) Name of the manufacturer, the month and year of manufacture, and the weight and type of section of rail as rolled.

(b) The heat number and the ingot number as rolled shall be stamped in the web of each rail where it will not be covered by the joint bars.

(c) The top rails shall normally be lettered "A", and succeeding ones "B", "C", "D", "E", etc., consecutively, but in case top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B", or other succeeding letter to suit the condition.

(d) All rails shall be branded "O-H" in addition to other marks.

Proposed Paragraph 16

Branding

16. Brands made so plain and sharp that they may be read as long as the rails are in service shall be rolled on or hot stamped into the side of the web of each rail in accordance with the following requirements:

(a) The data and order of arrangement of the Branding shall be as shown in the following Typical Brand, the design of letters and numerals to be optional with manufacturer.

11025	R. E.	O. H.	INLAND	1930	IIIIIII
(Weight & Sec. No.)	(Type)	(Kind of Steel)	(Manufacturer & Mill)	(Year Rolled)	(Month Rolled)

(b) The heat number and the ingot number as rolled shall be stamped in the web of each rail where it will not be covered by the joint bars. The data used in stamping and arrangement thereof shall be as shown in the following Typical Stamping:

EXAMPLE 1

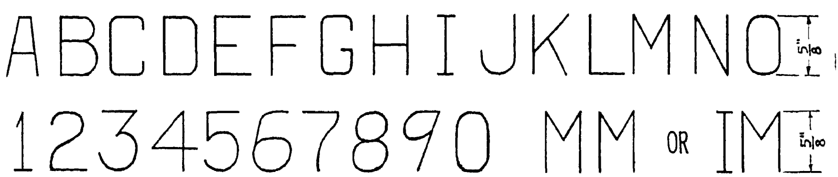
6 3 3 4 5 A B C D E F G H 17

(Heat Number) (Rail letter) (Ingot No.)

EXAMPLE 2

4 9 0 2 1 A B C D E F G H 5

(c) The top rails shall normally be lettered "A", and succeeding ones "B", "C", "D", "E", etc., consecutively, but in case top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B", or other succeeding letter to suit the condition. Design and size of letters and numerals to be used in stamping shall be as here shown:



REVISION OF FORM 402-A

While it was stated in last year's report that definite recommendations would be made this year for revision of Form 402-A, Report of Rail Failures in Main Track, such revision is not especially urgent and the Committee believes it may well await the outcome of the joint investigation which will possibly suggest the need for additional information concerning failures in track.

Recommendations

1. That carbon and manganese contents for 85 to 140 lb. rail and silicon content for all weights of rail as stipulated in paragraph 2 of Standard Specifications for Open-Hearth Carbon Steel Rails, page 148 of the Manual, be revised as shown in Table II presented above.

2. That sub-paragraph (e) of paragraph 17, of the Standard Specifications for Open-Hearth Steel Rails, page 151 of the Manual, be changed to read as given under "Classification Markings" above.

3. That paragraph 16 of the Standard Specifications for Open-Hearth Carbon Steel Rails as printed on page 151 of the 1929 Manual and repeated herewith, under the heading—"Present Paragraph 16", be revised to include the "Typical Branding", "Typical Stamping" and "Recommended Design of Letters and Numerals to be Used in Stamping", as adopted by the Association in 1931 and 1932 and appearing on pages 353 and 354 of the 1931 Proceedings, and be revised to read as given herewith under the heading "Proposed Paragraph 16".

Appendix B

(2) DETAILS OF MILL PRACTICE AND MANUFACTURE AS THEY AFFECT RAIL QUALITY AND RAIL FAILURES, GIVING SPECIAL ATTENTION TO TRANSVERSE FISSURE FAILURES, COLLABORATING WITH THE RAIL MANUFACTURERS' TECHNICAL COMMITTEE

Earl Stimson, Chairman, Sub-Committee; A. F. Blaess, W. C. Barnes, C. B. Bronson, E. E. Chapman, R. Faries, E. A. Hadley, J. V. Neubert, G. J. Ray, W. P. Wiltsee, L. Yager.

The general outline or program for the Joint Investigation being carried on at the University of Illinois by the Rail Committee and the Rail Manufacturers' Technical Committee, to determine the cause and remedy for transverse fissure and other rail failures, was published in the Committee's report to the March, 1932, Convention (A.R.E.A. Proceedings 1932, Vol. 33, pages 557-8).

The present status of this investigation is briefly given below:

5,000 tons of 130 lb. rail and 3,750 tons of 110 lb. rail have been rolled at five representative mills and service tests are in progress.

The work in the laboratory is being carried out in accordance with the general outline and is well under way. Deep etch tests have been made of all rails from the top, middle and bottom of the middle ingot of each heat and a large number of tensile, fatigue and chemical tests have been made. The high power microscopic work is well advanced and a number of Charpy impact tests of unnotched specimens cut from the rail heads have been completed.

Three roller test machines have been designed and constructed and are in constant use. These machines were constructed for the purpose of testing out the susceptibility of certain steels to the formation of transverse fissures.

For the purpose of correlating test results with studies of service stresses in rails, a series of fatigue tests have been started to determine the effect of range of stress on the fatigue strength of rail steel. Tests of rails subjected to wheel load accompanied by very slight bending moment and of rails subjected to bending moment without wheel load, have been started, the object being to separate the influence of wheel loads and of bending moment in producing fissures and to give a basis for the designing of a machine to test full size pieces of rails.

Analyses of the non-metallic and gas inclusions in rail steel have been started.

Various non-destructive methods of testing are being investigated in the endeavor to find one that is capable of differentiating between steel that is sound and that which contains minute interior defects.

It is too early in this important investigation for any conclusions or tentative conclusions to be drawn.

Appendix C-1

(3) RAIL FAILURE STATISTICS FOR 1931

By W. C. Barnes, Engineer of Tests, Rail Committee

The Rail Failure statistics for the year ending December 31, 1931 appearing in this report have been compiled in accordance with the standard method of basing the failure rates on mile years of service in track.

It should be noted that this is the first report in which the report year coincides with the calendar year, the report year having ended on October 31st in previous reports. All reports including that for this year cover twelve month periods, the transition having been made by omitting all data for the two months of November and December 1930.

The reported tonnages and track miles of rollings for 1926 and succeeding years embodied in these statistics are as follows:

Year Rolled	*Tons*	*Track Miles*
1926	1,858,499	11,203
1927	1,765,808	10,417
1928	1,667,336	9,686
1929	1,708,799	9,721
1930	1,058,342	6,030
Totals	8,058,784	47,057

Table 1 shows the average failures per 100 track miles of rail in service which occurred in one to five years service of all rail reported, from all mills, together with results taken from previous reports which include both Bessemer and Open-Hearth rail. The 1926 rollings, whose period of observation is now concluded show an average of 131.3 failures per 100 track miles during the five year period, an increase of 20.6 failures over those previously reported for the 1925 rollings. This is the highest rate of failure produced in any rollings since those of 1911 with exception of those for 1917. It appears from the failure rates shown in Table 1 for less than five years service of the 1927 and 1928 rollings that a return to a normal or subnormal rate will be reached when the 1928 rollings have completed their five years of service.

Fig. 1 shows diagrammatically the five year averages from Table 1.

Table 2 presents a summary from 19 annual reports showing track miles of rail originally laid and total failures in addition to the failures per 100 average track miles of rail in service for periods of one to five years.

Table 3 gives the failure rates of rail from each of the mills for rollings since 1908, for one to five-year periods.

Fig. 2 shows diagrammatically the data from Table 3. It will be seen from Fig. 2 and Table 3 that the high average 5 year rate for 1926 rollings from all mills is largely due to the high failure rates in the Ensley and Steelton rollings for 1926.

Table 4 presents a recapitulation of the performances during the five year period of rail rolled at each of the mills. In this table the original track miles laid from the various rollings are given as information, the failure rates being computed from the average track miles in service during the period.

Fig. 3 presents diagrammatically the average "per year" failure rates per 100 average track miles in service of the 1926 to 1930 rollings from the various mills from Table 4. These rates do not take into consideration the traffic carried. Inland shows the lowest failure rate of 6.80 followed closely by Minnequa with a rate of 7.71 and

Algoma with a rate of 9.67. At the lower end of the scale Maryland shows a 31.68 rate, Steelton a 31.85 rate and Ensley a 46.33 rate. The rates for the other mills are intermediate between those for the two groups just mentioned.

Fig. 4 rates the performances of the mills from the same data that underlie Fig. 3 except that relative traffic density factors have been introduced into the final computations. From the annual freight gross ton miles per mile of main track of each reporting road applied to its track mile years of rail of each of the 1926 to 1930 rollings from any given mill, the weighted average traffic over all of that mill's rail which was reported on, was determined. In like manner the weighted average traffic over all rail from each of the other mills was separately determined. The mill whose rail was subjected to the lightest traffic was then considered to have unit traffic density and relative traffic density factors were determined for each of the other mills, which were applied to the failure rates of the respective mill outputs given in Fig. 3. No claim is made that this method of rating is entirely accurate but it does give more consideration to the work which the rails from the various mills were called upon to perform than does the method of rating underlying Fig. 3 which takes no account of traffic.

The use of traffic density factors has resulted as follows: Inland remains in first position with the lowest rate of failure and Minnequa remains in second position. Edgar Thomson and Gary have moved up into third and fourth positions respectively. Tennessee remains in the lowest position and the differences between the rates for the other mills have been reduced.

Fig. 5 presents diagrammatically the "total" failure rate by mills and by year rolled from Table 4. The improvement in the 1928, 1929 and 1930 Ensley rollings is noteworthy.

Table 5 shows the average weights of rail from the various mills and from all mills. While the all-mill averages for the years 1926 to 1930 increased from 106.6 lb. to 111.6 lb. per yard, there was no increase in average weight from 1929 to 1930.

TABLE 1

AVERAGE FAILURES PER 100 TRACK MILES—ALL MILLS

Year Rolled	Years Service 1	2	3	4	5
1908					398.1
1909				224.1	277.8
1910			124.0	152.7	198.5
1911		77.0	104.4	133.3	176.8
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	110.0
1923	14.3	33.2	57.6	86.0	114.1
1924	14.0	33.4	58.3	82.0	110.7
1925	15.5	36.6	58.3	76.6	110.7
1926	17.1	41.2	64.6	102.6	131.3
1927	18.4	37.7	69.5	94.6	
1928	11.0	28.0	45.8		
1929	14.1	36.8			
1930	7.8				

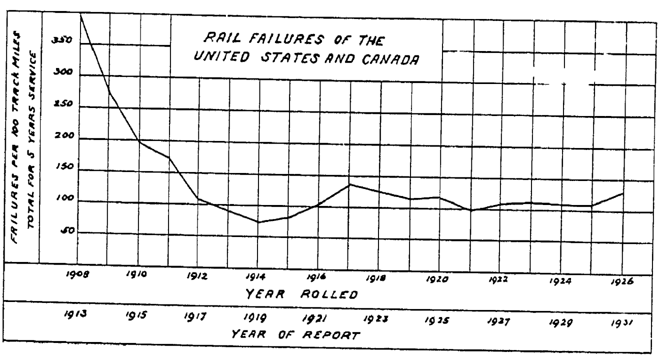


FIG. 1.

TABLE 2

SUMMARY FROM NINETEEN ANNUAL REPORTS SHOWING TRACK MILES ORIGINALLY LAID, TOTAL FAILURES AND FAILURES PER 100 AVERAGE TRACK MILES IN SERVICE

Service	*Five Years*			*Four Years*			*Three Years*			*Two Years*			*One Year*		
	Trk Mls of Rail Laid	Failures		Trk Mls Of Rail	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Failures	
		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls
FROM 1913 REPORT															
Year Rolled Totals	3201.35	1908 12746	398.1	6340.54	1909 14208	224.1	9860.18	1910 12227	124.0	6536.05	1911 5030	77.0	7105.74	1912 2050	28.9
FROM 1914 REPORT															
Year Rolled Totals	6697.39	1909 18605	277.8	10024.85	1910 15309	152.7	6096.48	1911 6354	104.4	7610.60	1912 2431	32.1	8775.44	1913 1095	12.5
FROM 1915 REPORT															
Year Rolled Totals	11587.43	1910 22981	198.5	7980.75	1911 10635	133.3	10374.18	1912 5119	49.3	10668.59	1913 2756	25.8	7061.24	1914 584	8.2
FROM 1916 REPORT															
Year Rolled Totals	7969.41	1911 14052	176.3	10260.93	1912 8100	78.9	11335.41	1913 5076	44.8	7505.24	1914 1483	19.8	7381.29	1915 656	8.9
FROM 1917 REPORT															
Year Rolled Totals	10778.68	1912 11546	107.1	12526.60	1913 8706	69.5	7819.79	1914 2576	32.9	7344.65	1915 1395	19.0	8532.53	1916 1004	11.8
FROM 1918 REPORT															
Year Rolled Totals	11883.57	1913 10924	91.9	7752.27	1914 3948	50.9	7072.23	1915 2414	34.2	8347.44	1916 2430	29.2	7384.26	1917 1596	21.6

TABLE 2—Continued

SUMMARY FROM NINETEEN ANNUAL REPORTS SHOWING TRACK MILES ORIGINALLY LAID, TOTAL FAILURES AND FAILURES PER 100 AVERAGE TRACK MILES IN SERVICE—Continued

Service	*Five Years*			*Four Years*			*Three Yeass*			*Two Years*			*One Year*		
	Trk Mls of Rail Laid	Failures		Trk Mls Of Rail	Failures		Trk Mls Of Rail Laid	Failures		Trk Mls Of Rail Laid	Fai.ures		Trk Mls Of Rail Laid	Failures	
		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls
FROM 1919 REPORT															
Year Rolled Totals	7917.26	1914 5855	74.0	7280.51	1915 3862	53.0	8407.55	1916 4013	47.7	7615.46	1917 2962	38.9	6354.44	1918 568	8.9
FROM 1920 REPORT															
Year Rolled Totals	7346.50	1915 6057	82.4	8062.10	1916 5691	70.6	7334.40	1917 4844	66.0	6658.80	1918 1837	27.6	6676.60	1919 986	14.8
FROM 1921 REPORT															
Year Rolled Totals	7820.14	1916 8248	105.4	7025.25	1917 7765	110.5	6313.98	1918 3414	54.0	6271.82	1919 2477	39.4	7341.71	1920 1044	14.2
FROM 1922 REPORT															
Year Rolled Totals	6945.43	1917 9533	137.0	6117.93	1918 5681	92.8	6402.43	1919 4719	73.7	7550.63	1920 2448	32.4	7421.29	1921 806	10.9
FROM 1923 REPORT															
Year Rolled Totals	5756.11	1918 7221	125.4	6388.57	1919 6697	104.8	7200.83	1920 4545	63.1	7338.52	1921 2568	34.9	7116.16	1922 1135	15.9
FROM 1924 REPORT															
Year Rolled Totals	5913.86	1919 6845	115.7	7271.00	1920 6146	84.5	6857.55	1921 3905	56.9	6974.38	1922 2429	34.8	9501.95	1923 1363	14.3

From 1925 Report

Year Rolled Totals	6576.48	1920 7759	119.6	6640.46	1921 4950	70.9	6765.99	1922 3514	55.2	8692.16	1923 2791	33.2	7804.78	1924 1098	14.0

From 1926 Report

Year Rolled Totals	7686.27	1921 7376	98.9	7116.14	1922 5594	80.4	9737.02	1923 5454	57.6	9371.49	1924 3130	33.4	10838.62	1925 1701	15.5

From 1927 Report

Year Rolled Totals	6997.42	1922 7341	110.0	9657.09	1923 7809	86.0	9036.17	1924 5014	58.3	10344.83	1925 3620	36.6	10380.45	1926 1742	17.1

From 1928 Report

Year Rolled Totals	8106.35	1923 9253	114.1	7916.99	1924 6493	82.0	9159.06	1925 5342	58.3	9286.90	1926 3824	41.2	8527.64	1927 1567	18.4

From 1929 Report

Year Rolled Totals	8817.34	1924 9201	110.7	10276.68	1925 7672	76.6	11164.54	1926 6945	64.6	9951.44	1927 3675	37.7	9518.72	1928 1027	11.0

From 1930 Report

Year Rolled Totals	10161.96	1925 10697	110.7	11234.30	1926 10662	102.6	10085.95	1927 6741	69.5	9510.08	1928 2544	28.0	9229.51	1929 1253	14.1

From 1931 Report

Year Rolled Totals	11202.92	1926 13967	131.3	10417.05	1927 9141	94.6	9686.46	1928 4246	45.8	9721.24	1929 3390	36.8	6029.69	1930 470	7.8

TABLE 3

FAILURES PER 100 TRACK MILES IN 1908 TO 1930 ROLLINGS IN ONE TO FIVE YEAR SERVICE PERIODS BY MILLS

Years Service	Year Rolled																						
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
ALGOMA																							
1					124.0		19.0	7.1	22.7	2.0		7.3	2.6	4.6	17.4	30.3	18.5	2.3	1.2	21.1	6.7	3.6	2.3
2				219.7			43.2	11.8	42.1	2.0		26.6	16.5	13.4	51.7	74.5	48.9	7.9	7.5	45.0	15.4	5.2	
3			431.0				67.1	22.9	63.4	9.1		55.8	41.0	27.0	83.0	115.8	85.7	30.3	18.8	69.9	30.7		
4		203.7					67.9	39.1	96.8	29.7		82.9	278.5	42.4	125.5	161.8	151.5	59.6	32.3	94.4			
5	482.9		13.8				321.4	84.0	139.9	62.9		36.7	472.0	65.2	184.4	276.3	236.2	113.3	52.7				
CAMBRIA—(Bethlehem)																							
1					17.1	26.7	15.8	6.3	7.3	23.9	32.9	33.3	37.6	13.8	16.1	12.6							
2				73.7	41.8	49.5	37.7	19.5	25.9	38.9	95.5	75.2	44.2	43.2	43.9	36.9							
3			98.5	126.1	74.3	78.3	61.9	34.1	33.7	112.9	248.0	82.6	96.8	101.2	62.0	63.3							
4		244.8	136.4	227.7	108.9	106.2	64.3	58.7	73.7	311.6	369.7	103.2	158.5	158.8	72.0	97.3							
5		326.6	201.0	257.2	140.9	120.1	137.7	111.5	157.6	394.2	507.4	152.7	223.1	237.4	126.0	123.5							
EDGAR THOMSON—(Carnegie)																							
1					12.3	8.9	5.5	1.8	4.9	6.1	6.2	8.5	7.0	3.3	8.4	4.1	10.6	17.1	17.2	11.2	10.3	6.2	11.6
2				71.5	30.9	19.4	11.9	8.6	13.2	19.5	41.6	35.9	15.1	8.6	20.4	13.9	33.8	41.9	30.9	23.4	31.5	31.0	
3			98.9	108.9	55.3	33.8	16.6	16.9	26.8	39.3	50.2	36.5	34.4	23.6	38.0	26.0	48.4	53.0	50.9	42.7	66.1		
4		104.1	112.9	123.1	78.4	62.9	25.4	29.2	45.6	73.3	73.7	46.5	59.4	37.5	48.7	45.9	63.0	74.8	81.5	98.5			
5		137.1	101.1	165.6	98.8	80.0	48.8	43.7	69.7	92.2	125.5	60.5	87.8	52.8	65.5	58.2	79.3	102.5	120.7				
DOMINION																							
1												5.7		60.9				2.6	1.3	6.3	5.3	6.4	0.0
2											60.0	102.3						2.6	5.8	14.2	15.9	12.6	
3											149.0	185.9						2.7	24.0	25.3	26.8		
4											420.9	298.3						7.1	49.9	41.1			
5											482.7	396.0						22.1	86.2				

ENSLEY—(Tennessee)

1					7.3	5.7	7.5	6.0	15.6	17.3	16.4	14.1	39.9	37.5	42.7	42.4	32.6	35.5	34.6	48.4	12.6	17.9	18.4
2				14.9	32.9	16.5	16.6	16.0	37.1	35.7	34.6	34.2	83.1	84.9	106.7	100.4	82.4	96.1	89.9	113.6	31.9	30.5	
3			32.4	25.1	43.9	24.5	29.0	30.5	61.1	58.2	79.9	100.7	149.3	149.7	172.0	136.2	136.4	160.3	150.5	222.4	41.1		
4		11.1	47.8	40.8	64.5	41.6	44.2	48.0	82.2	102.5	143.1	132.3	189.8	184.7	204.7	194.5	181.5	168.7	241.1	258.2			
5	86.5	83.7	55.2	61.7	83.2	57.3	60.8	70.9	123.4	109.5	145.3	79.7	232.4	231.6	264.9	245.3	249.6	252.3	286.4				

GARY—(Illinois) includes So. Works to 1919 inclusive

1					7.4	10.0	11.6	10.7	11.1	9.1	2.5	11.5	5.4	4.2	5.0	6.6	5.4	5.6	8.2	12.8	12.0	11.3	3.6
2				67.5	28.2	21.9	30.0	21.9	26.0	19.9	10.8	26.8	13.3	16.2	11.2	17.2	10.9	10.9	22.9	20.4	24.2	20.4	
3			88.4	94.0	39.2	44.0	47.3	40.9	43.9	46.3	18.5	43.7	86.9	27.0	20.6	32.5	18.8	20.9	42.7	30.9	31.5		
4		151.9	136.8	107.7	64.6	62.1	83.6	56.1	70.7	75.5	45.4	77.1	55.6	41.7	29.4	51.1	23.2	34.5	68.4	45.7			
5		219.7	206.2	178.6	100.0	91.5	98.3	78.8	97.3	107.7	50.3	107.1	84.2	58.9	42.6	72.9	44.4	50.3	98.4				

INLAND

1																7.6	2.6	5.6	10.7	2.5	4.6	4.1	1.4
2															19.0	12.8	6.7	10.4	16.7	7.8	12.1	8.0	
3															35.7	20.4	16.7	21.8	30.8	13.4	17.9		
4															53.1	29.5	22.2	30.1	44.3	19.9			
5															75.7	33.4	38.2	44.2	51.2				

LACKAWANNA—(Bethlehem)

1					4.8	17.2	1.8	10.5	8.9	16.8	7.4	22.8	14.5	3.8	4.0	18.6	18.5	16.7	24.6	37.1	8.6	28.0	7.0
2				29.5	20.1	31.4	10.0	23.8	25.5	31.6	23.7	51.9	27.1	19.0	13.6	35.9	29.3	36.0	41.9	33.0	17.5	57.3	
3			42.7	57.1	39.6	51.9	24.5	38.1	40.1	46.6	43.8	77.4	50.6	41.3	22.6	57.6	50.8	50.9	50.3	49.3	27.4		
4		100.1	90.3	108.6	67.1	74.0	49.3	57.3	58.0	78.3	65.5	86.7	74.1	62.4	36.6	90.8	59.5	86.8	78.6	70.7			
5	143.5	117.8	148.9	162.5	88.6	115.3	78.7	73.1	76.9	104.5	93.2	153.0	99.0	83.2	49.9	108.6	97.2	122.3	105.0				

MARYLAND—(Bethlehem)

1					11.3	28.6	13.3	24.5	30.7	160.5	23.7	34.2	0.0	0.0				11.2	31.0	62.1	20.2	15.6	3.4
2				32.9	5.8	74.1	25.2	60.2	61.8	214.2	59.2	52.8	2.3	7.2			1.5	62.6	72.9	53.5	37.6	147.8	
3			69.6	49.5	18.1	88.4	31.4	99.6	92.6	360.5	113.6	60.8	11.9	25.3			6.0	61.9	53.2	85.4	52.9		
4			104.8	58.5	8.6	117.0	36.2	138.1	96.6	425.5	139.1	90.8	11.9				35.4	55.9	53.8	131.2			
5			163.7	67.4	110.8	159.7	62.9	231.4	180.3	445.5	210.3	106.9				180.0	65.4	77.1	97.4				

TABLE 3—Continued

FAILURES PER 100 TRACK MILES IN 1908 TO 1930 ROLLINGS IN ONE TO FIVE YEAR SERVICE PERIODS BY MILLS

Years Service	Year Rolled 1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
MINNEQUA—(Colorado)																							
1					18.3	3.9	3.7	4.6	5.8	5.4	6.5	5.0	9.3	9.2	12.0	7.0	4.3	3.8	2.8	2.1	3.8	2.0	2.7
2				15.8	40.9	11.0	7.6	7.7	15.7	12.5	13.1	18.5	27.6	31.7	27.1	29.3	9.6	7.2	8.9	4.6	22.7	6.0	
3			19.6	31.0	55.6	26.0	14.1	15.1	34.5	36.7	39.7	32.9	75.0	50.6	58.9	54.3	28.7	19.1	20.0	12.3	43.4		
4		22.4	23.4	52.6	91.3	46.6	27.3	34.4	53.6	51.5	109.0	65.2	96.5	72.7	111.6	91.5	39.2	32.0	30.6	19.7			
5	45.5	34.2	60.9	84.3	117.6	82.1	42.0	80.3	78.1	42.6	184.8	90.2	138.3	97.8	136.6	108.9	57.8	47.6	46.3				
SAUCON—(Bethlehem)																							
1					11.9	13.4	3.8	17.1	17.7	39.0	19.6	31.2	10.5	12.9	55.6								
2				113.3	32.0	26.9	6.9	24.5	42.4	59.2	57.7	72.3	57.5	63.4	77.3								
3			174.0	195.3	52.1	52.6	16.0	41.0	75.2	94.8	78.4	105.0	56.5	88.4	130.6								
4		466.1	245.0	251.7	83.2	77.3	21.6	65.0	110.9	127.7	91.5	160.7	84.5	114.3	177.4								
5	503.7		330.9	329.8	106.8	99.5	33.0	92.4	152.0	157.5	133.7	213.9	95.5	143.5	223.4								
STEELTON—(Bethlehem)																							
1					5.3	9.6	8.2	6.3	35.6		2.4	46.9	56.3	4.9	10.3	10.0	16.6	7.8	20.2	13.7	21.3	40.8	19.8
2				34.6	15.6	21.0	21.1	18.1	46.1		9.2	79.6	38.5	12.2	18.7	16.7	38.9	34.3	41.0	34.4	56.1	88.0	
3			81.4	79.6	27.5	34.7	29.4	27.9	94.2		20.7	139.8	73.2	25.9	20.1	31.2	65.3	50.6	62.3	77.2	105.1		
4		86.3	110.9	119.0	46.8	47.2	38.0	48.4	136.1		50.6	175.1	96.7	41.6	29.7	41.1	80.1	77.5	107.8	104.8			
5	72.9	101.4	123.8	145.2	60.4	71.2	49.7	59.6	171.7		76.0	233.8	139.5	66.1	43.9	49.4	95.9	113.2	144.9				
ALL MILLS																							
1					26.3	11.5	8.0	8.8	11.7	21.8	8.9	14.8	14.2	10.8	15.9	14.3	14.0	15.5	17.1	18.4	11.0	14.1	7.8
2				53.0	28.9	24.8	18.9	19.0	27.9	38.9	27.6	39.4	32.4	34.9	34.8	33.2	33.4	36.6	41.2	37.7	28.0	36.8	
3			81.3	83.5	46.0	43.3	30.8	33.8	47.7	66.0	54.0	73.7	63.1	56.9	55.2	57.6	58.3	58.3	64.6	69.5	45.8		
4		163.6	107.1	111.2	74.2	68.5	47.4	53.0	70.6	110.5	92.8	104.8	84.5	70.9	80.4	86.0	82.0	76.6	102.6	94.6			
5	370.5	198.5	154.0	161.9	102.7	90.3	74.0	82.4	105.4	137.0	125.4	115.7	119.6	98.9	110.0	114.1	110.7	110.7	131.3				

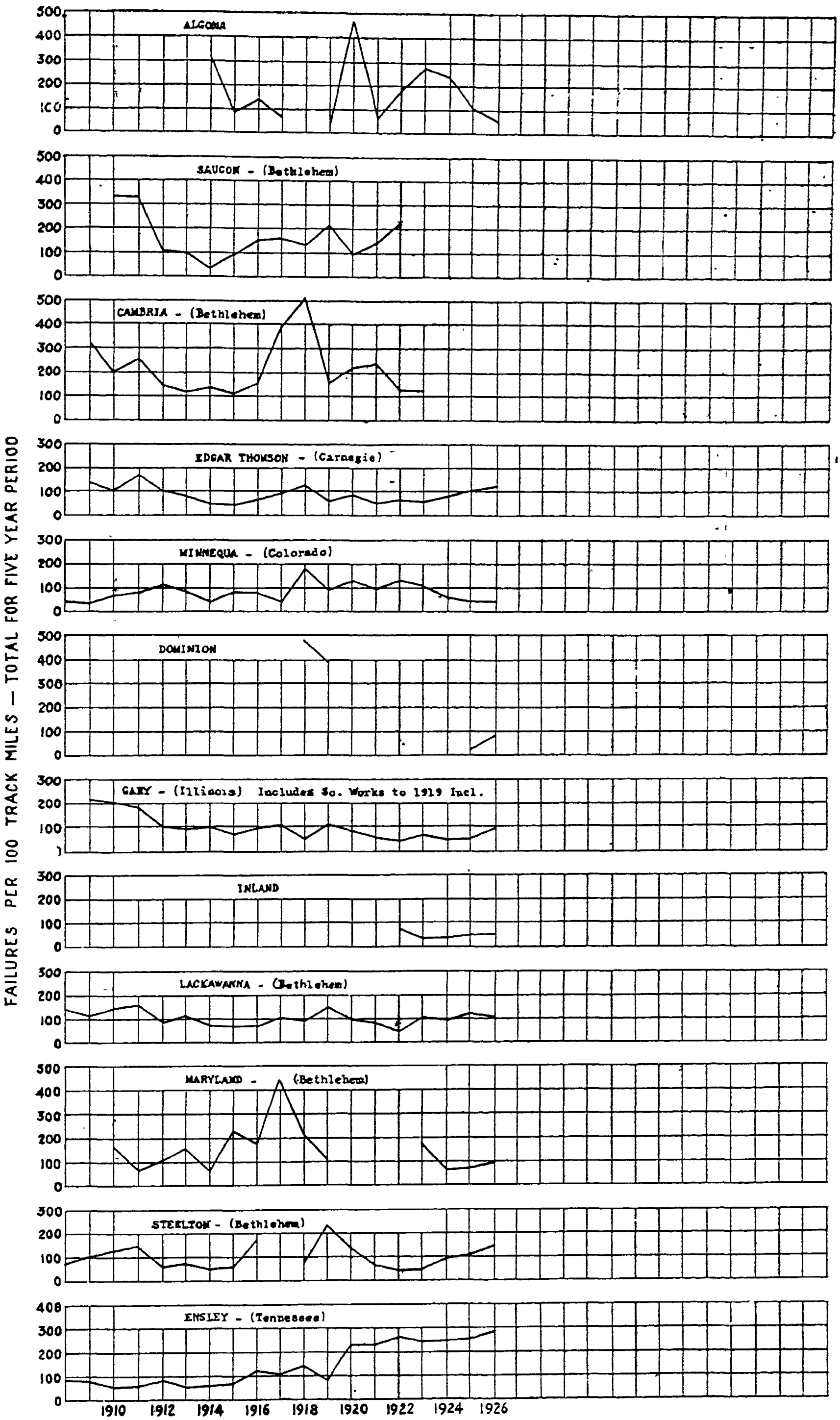

FAILURES PER 100 TRACK MILES — TOTAL FOR FIVE YEAR PERIOD
ALGOMA
SAUCON - (Bethlehem)
CAMBRIA - (Bethlehem)
EDGAR THOMSON - (Carnegie)
MINNEQUA - (Colorado)
DOMINION
GARY - (Illinois) Includes So. Works to 1919 Incl.
INLAND
LACKAWANNA - (Bethlehem)
MARYLAND - (Bethlehem)
STEELTON - (Bethlehem)
ENSLEY - (Tennessee)
1910 1912 1914 1916 1918 1920 1922 1924 1926

TABLE 4

RECAPITULATION—TOTALS AND AVERAGES GROUPED BY MILLS. TRACK MILES—REPRESENT QUANTITIES ORIGINALLY LAID. FAILURES TO DATE—COMPUTED BY MILE YEARS OF RAIL IN SERVICE

Year Rolled	Original Trk. Mls.	Total Failures	Failures to Date Per 100 Av. Trk.Mls. Total	Failures to Date Per 100 Av. Trk.Mls. Per Year	Original Trk. Mls.	Total Failures	Failures to Date Per 100 Av. Trk.Mls. Total	Failures to Date Per 100 Av. Trk.Mls. Per Year
	ALGOMA				DOMINION			
1926	319.36	168	52.7	10.5	154.24	133	86.2	17.2
1927	188.97	178	94.4	23.6	63.59	26	41.1	10.3
1928	793.86	244	30.7	10.2	119.35	32	26.8	8.9
1929	772.26	52	5.2	2.6	63.49	8	12.6	6.3
1930	484.86	11	2.3	2.3	63.88	0	0.0	0.0
Totals	2559.31	653	Ave.	9.7	464.55	199	Ave.	12.6
	EDGAR THOMSON (Carnegie)				ENSLEY (Tennessee)			
1926	1433.95	1634	120.7	24.1	2104.95	5775	286.4	57.3
1927	1365.07	1016	98.5	24.6	1675.97	4051	258.2	64.5
1928	1167.24	729	66.1	22.0	1402.22	549	41.1	13.7
1929	1377.21	406	31.0	15.5	1135.47	333	30.5	15.2
1930	750.37	87	11.6	11.6	906.98	167	18.4	18.4
Totals	6093.84	3872	Ave.	21.6	7225.59	10875	Ave.	46.3
	GARY (Illinois)				INLAND			
1926	2544.97	2377	98.4	19.7	875.87	416	51.2	10.2
1927	2353.47	1045	45.7	11.4	880.90	165	19.9	5.0
1928	2225.44	669	31.5	10.5	754.15	125	17.9	6.0
1929	1961.82	364	20.4	10.2	682.96	51	8.0	4.0
1930	1321.70	48	3.6	3.6	490.03	7	1.4	1.4
Totals	10407.40	4503	Ave.	13.9	3683.91	764	Ave.	6.8
	LACKAWANNA (Bethlehem)				MARYLAND (Bethlehem)			
1926	1253.63	1185	105.0	21.0	351.03	322	97.4	19.5
1927	973.19	623	70.7	17.7	581.72	722	131.2	32.8
1928	719.48	179	27.4	9.1	444.94	227	52.9	17.6
1929	953.29	519	57.3	28.7	575.36	786	147.8	73.9
1930	483.00	34	7.0	7.0	324.06	11	3.4	3.4
Totals	4382.59	2540	Ave.	18.9	2277.11	2068	Ave.	31.7
	MINNEQUA (Colorado)				STEELTON (Bethlehem)			
1926	1108.66	508	46.3	9.3	1056.26	1449	144.9	21.0
1927	1263.07	247	19.7	4.9	1071.10	1068	104.8	26.2
1928	1024.40	441	43.4	14.5	1035.38	1051	105.1	35.0
1929	1220.78	72	6.0	3.0	978.60	799	88.0	44.0
1930	778.95	21	2.7	2.7	425.86	84	19.8	19.8
Totals	5395.86	1289	Ave.	7.7	4567.20	4451	Ave.	31.8
	ALL MILLS							
1926	11202.92	13967	131.3	26.3				
1927	10417.05	9141	94.6	23.6				
1928	9686.46	4246	45.8	15.2				
1929	9721.24	3390	36.8	18.4				
1930	6029.69	470	7.8	7.8				
Totals	47057.36	31214	Ave.	21.5				

DIAGRAM SHOWING MILL RATINGS—COMPILED BY USUAL METHOD.

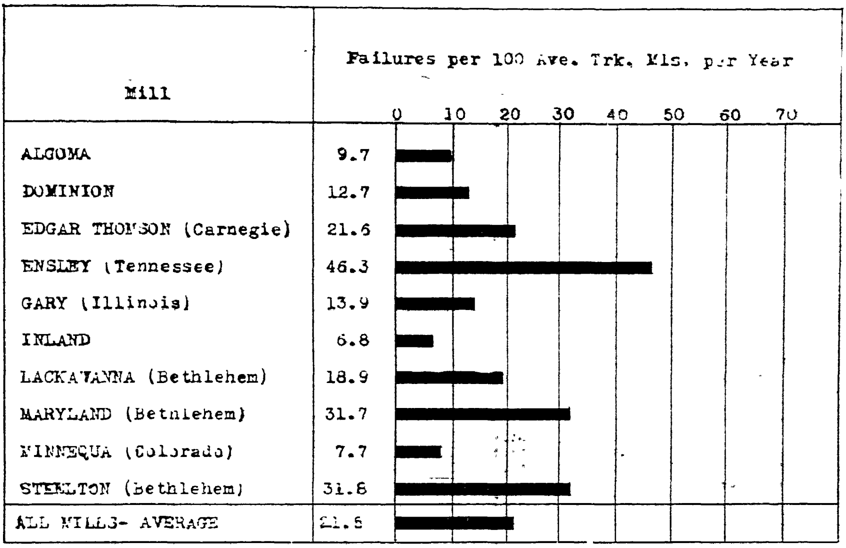


FIG. 3—Average Failure Rates for the Rollings of 1926 to 1930 inclusive, classified by Mills.

DIAGRAM SHOWING MILL RATINGS—AS ALTERED BY USE OF TRAFFIC DENSITY FACTORS.

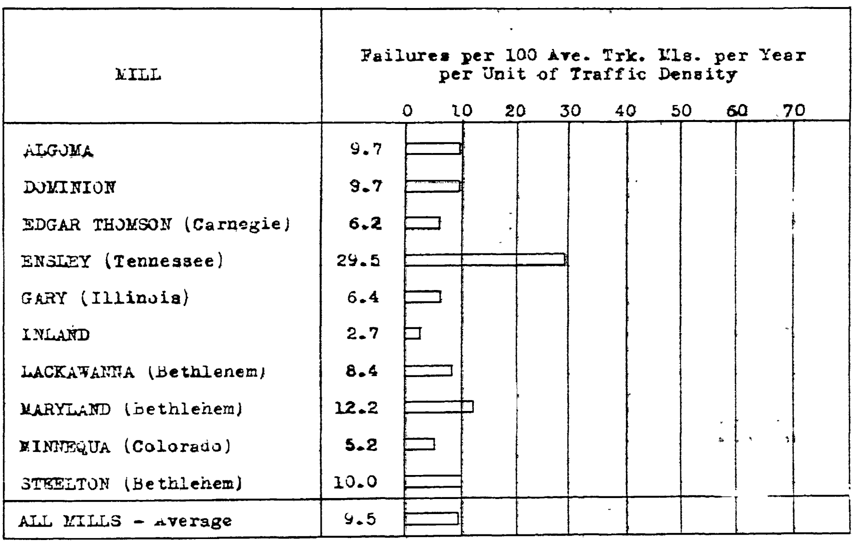


FIG. 4—This diagram is presented as information only. It shows average failure rates for the rollings of 1926 to 1930 inclusive, classified by mills, changed from those presented in Fig. 3.

DIAGRAM SHOWING FAILURES PER 100 AVERAGE TRACK MILES BY MILL AND BY YEAR ROLLED FOR PERIODS ENDING DECEMBER 31, 1931.

MILL	Year Rolled	Failures per 100 Average Track Miles
ALGOMA	1926	52.7
	1927	94.4
	1928	30.7
	1929	5.2
	1930	2.3
DOMINION	1926	86.2
	1927	41.4
	1928	26.8
	1929	12.6
	1930	0.0
EDGAR THOMSON (Carnegie)	1926	120.7
	1927	98.5
	1928	66.1
	1929	31.0
	1930	11.6
ENSLEY (Tennessee)	1926	286.4
	1927	258.2
	1928	41.1
	1929	30.5
	1930	18.4
GARY (Illinois)	1926	98.4
	1927	45.7
	1928	31.5
	1929	20.4
	1930	3.6
INLAND	1926	51.2
	1927	19.9
	1928	17.9
	1929	8.0
	1930	1.4
LACKAWANNA (Bethlehem)	1926	105.0
	1927	70.7
	1928	27.4
	1929	57.3
	1930	7.0
MARYLAND (Bethlehem)	1926	97.4
	1927	131.2
	1928	52.9
	1929	147.8
	1930	3.4
MINNEQUA (Colorado)	1926	46.3
	1927	19.7
	1928	43.4
	1929	6.0
	1930	2.7
STEELTON (Bethlehem)	1926	144.9
	1927	104.8
	1928	105.1
	1929	88.0
	1930	19.8
ALL MILLS (Average)	1926	131.3
	1927	94.5
	1928	45.8
	1929	36.8
	1930	7.8

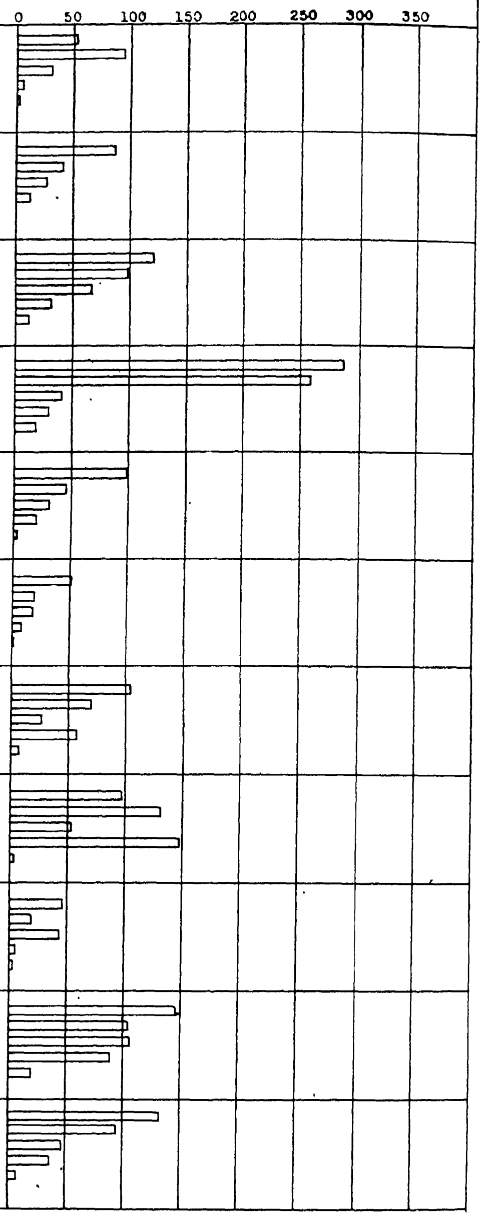


FIG. 5—Accumulated Failures for Rollings from 1926 to 1930 inclusive.

TABLE 5

AVERAGE WEIGHTS OF RAILS COMPILED FROM TONNAGES USED IN THIS REPORT

Mill	1926	1927	1928	1929	1930
Algoma	100.7	100.3	100.8	101.2	101.0
Dominion	101.4	101.4	114.9	126.9	126.9
Edgar Thomson (Carnegie)	114.4	115.0	119.7	121.0	122.9
Ensley (Tennessee)	97.3	100.1	103.0	101.8	102.7
Gary (Illinois)	103.5	106.2	108.8	111.2	108.7
Inland	102.2	105.1	108.3	110.5	109.3
Lackawanna (Bethlehem)	108.5	107.2	105.5	114.6	119.0
Maryland (Bethlehem)	106.7	112.9	115.5	116.2	113.8
Minnequa	98.1	102.4	101.7	104.3	107.5
Steelton (Bethlehem)	123.2	122.5	122.5	123.8	129.7
All Mills	106.6	107.8	109.4	111.8	111.6

Appendix C-2

(3) TRANSVERSE FISSURE STATISTICS

By W. C. Barnes, Engineer of Tests, Rail Committee

These statistics constitute a cumulative record of 58,227 transverse fissure failures which have been reported up to and including December 31st, 1931. They include all fissured rails reported whether located by actual breakage in track or detected before breakage by inspection or test.

Table I corresponds with Table I of last year's report and shows the number of transverse fissure failures reported by each of 54 roads and the years in which such failures occurred. In previous reports the detected failures were shown separately for the current year only and were included with the service failures for prior years, thus making reference to earlier reports necessary to determine the service and detected failures separately for those prior years. In this report Table 1 has been improved to show a continuing record of the service failures only and likewise of the detected failures. The total failures for any year on any road can be obtained by adding the service failures and the detected failures for that year on that road.

Prior to 1930, the report year started on February 1st but in 1930 it was changed to coincide with the calendar year. To effect this change, the data given for the transition year 1930 covered eleven months only, viz., from February 1st to December 31st. The data for 1931 covers twelve months from January 1st.

The accumulated grand total of fissure failures, service and detected, reported to December 31st, 1931 from all rollings was 58,227 or an addition during the year 1931 of 7481. This is an increase of 770 over the total of 6711 reported for the eleven months of 1930, but is only 159 more than said total prorated for twelve months of 1930, namely 7322. This increase is more than accounted for by the detection during 1931 of 2686 fissured rails which is 1232 more than the 1454 detected during the eleven months of 1930.

The total service failures for the twelve months of 1931 were 4795 compared with a like total for the eleven months of 1930 of 5257, a decrease in actual breakage in track of 462. The increase shown in the number of detected fissures is not an indication of greater prevalence of fissures but of increased efficiency and use of methods of locating them in track before actual breakage. Many fissured rails were detected during the year on roads which do not report fissure failures and hence are not included in Table I.

Fig. 1 presents graphically the total fissure failures reported each year. The dotted curve includes "detected" fissure failures while the solid curve excludes them. For ten years prior to 1929 the number of fissured rails which broke in track annually, increased at an average rate of 426 per year. Whereas since 1929, the first year in which detection methods were used to any appreciable extent the annual total of actual breaks (i. e., exclusive of detected failures) has decreased at an average rate of 482 per year.

Table 2 corresponds with Table 2 of last year's report. It shows all transverse fissure failures accumulated from year rolled to December 31, 1931, for each year's rollings from each mill, unweighted by tonnage output of mills, by density of traffic or by years of service.

This table is most useful in comparing the failures in the various year's rollings from any one mill. Of the earlier rollings, those of 1910, 1912, 1913 and 1917 from all mills continue to show the largest number of accumulated failures while of the more recent rollings, those of 1926 have produced the greatest number principally due to failures in Tennessee rail. The reduced number of failures in Tennessee rail rolled since

Fissure failures reported since 1924 as occurring in the first year of service are as follows:

29	failures	in	1925	from	1925	Rollings,	All	Mills
50	"	"	1926	"	1926	"	"	"
114	"	"	1927	"	1927	"	"	"
58	"	"	1928	"	1928	"	"	"
106	"	"	1929	"	1929	"	"	"
33	"	"	1930	"	1930	"	"	"
32	"	"	1931	"	1931	"	"	"

Of the 32 failures in the 1931 rollings, 19 occurred in Steelton rail, 12 in Sparrows Point and 1 in Gary rail.

Table 3 corresponds with Table 3 of last year's report and shows the rate of accumulated failures on selected roads per 100 original track miles per year from year rolled to December 31, 1931. The data included are for the rollings of 1924 to 1928 inclusive and are segregated by mill and by year rolled. No account is taken in this table of differences in density of traffic over the rails from the various mills. Table 3 includes a total of 9367 fissure failures which occurred in 35,593 miles of track.

The 1930 and 1931 failures included in Table 3, Fig. 2 and Fig. 3 are those which occurred during the 12 months of the new report year which corresponds to the calendar year, while those for former years are for the old report year which ended with January 31st. Both the 1929 and 1930 failures include those that occurred in January 1930. This procedure was employed to preserve the "Per Year" basis of Table 3, Fig. 2 and Fig. 3.

Colorado, Inland and Gary mills show the lowest average accumulated failure rates per 100 track miles per year from date rolled to December 31, 1931, in the order named, the respective rates being 0.43, 2.05 and 2.71. Tennessee and Maryland show the highest rates of 11.17 and 20.54 respectively. Study of the Table 3 and of reports of later year's rollings in Table 2 indicate that Tennessee's average record will improve at least until the 1927 rollings disappear from the table. On the contrary, the Maryland and Steelton average rates are definitely on the increase.

Fig. 2 shows graphically the average rates of failure by mills from Table 3.

Fig. 3 shows graphically the average rates of failure by mills from Table 3 modified by the application of average traffic density factors. The method of obtaining these factors has been explained in detail in preceding reports.

The weighting for relative traffic density has improved the rates of those mills whose rails carried the heavier traffic and has resulted in putting Carnegie in third place instead of Gary.

FIG. 1—Total Fissure Failures Reported Each Year (1930 includes 11 months only).

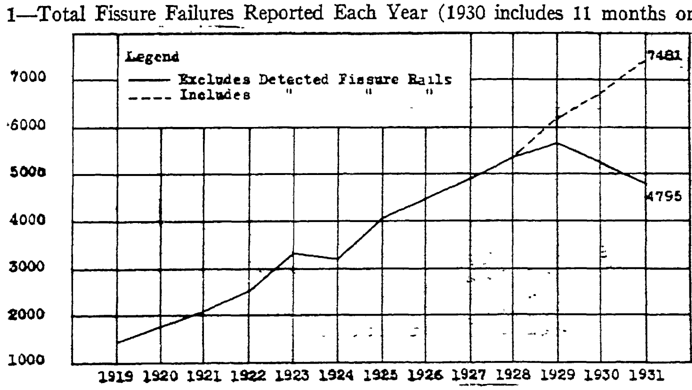


TABLE 1

TRANSVERSE FISSURE FAILURES BY RAILROADS AND YEAR FAILED

Railroad	Service Failures															Detected Failures**				Grand Total
	Prior	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930*	1931	Total	1929	1930*	1931	Total	
A. T. & S. F.	40	25	177	220	134	126	81	79	71	98	126	91	142	114	1524	--	--	--	--	1524
A. C. L.	--	--	--	--	--	--	--	--	11	9	27	25	21	29	122	--	66	--	66	188
Ban. & Aroos.	--	--	--	--	--	--	--	--	11	2	0	4	7	2	26	--	--	--	--	26
B. & Eastern	--	--	--	--	--	--	0	0	0	0	0	0	0	0	0	--	--	--	--	0
Boston & Albany	4	17	23	30	25	15	10	9	3	12	8	31	31	26	244	--	23	29	52	296
Boston & Maine	--	--	--	--	--	35	69	72	78	70	44	34	35	22	459	--	17	--	17	476
B. & O.	--	--	--	--	--	212	297	369	253	458	405	428	345	472	3239	53	--	--	53	3292
B. R. & P.	--	--	--	--	9	11	9	16	15	17	26	41	27	34	205	--	--	--	--	205
Can. Nat.	--	--	--	--	--	--	--	--	13	--	--	--	--	--	13	--	--	--	--	13
Can. Pacific	--	4	--	8	16	59	86	158	277	174	160	108	138	106	1294	--	--	351	351	1645
Cent. of Ga.	106	52	23	41	31	29	24	40	20	20	42	92	80	42	642	--	80	--	80	722
C. R. R. of N. J.	--	--	--	--	--	--	--	--	--	34	58	95	73	59	319	--	35	111	146	465
C. & E. I.	--	--	--	--	--	--	--	--	4	--	22	41	18	18	103	28	--	59	87	190
C. & O.	--	--	--	6	26	46	49	81	208	104	165	167	181	239	1245	19	376	667	1062	2307
C. & N. W.	--	--	--	--	--	--	--	--	85	63	47	62	101	86	444	16	31	110	157	601
C. B. & Q.	--	1	7	34	101	87	--	--	--	--	--	--	--	--	230	--	--	--	--	230
C. M. St. P. & P.	2	--	6	5	14	11	11	13	5	9	26	11	26	45	184	43	--	49	92	276
C. R. I. & P.	10	2	11	25	37	75	73	114	98	97	90	123	111	116	982	20	--	18	38	1020
C. C. C. & St. L.	--	--	--	--	2	1	1	47	21	11	36	44	44	27	234	--	--	--	--	234
D. L. W.	474	193	240	169	91	80	73	113	128	86	92	139	98	64	2040	--	--	--	--	2040
El Paso & S. W.	--	--	--	--	8	6	(See	Sou. P	ac.)	--	--	--	--	--	14	--	--	--	--	14
Erie	--	--	--	--	15	43	89	100	118	148	128	235	156	175	1207	27	2	1	30	1237
Great Northern	--	--	--	--	--	--	--	--	--	58	221	175	189	141	784	--	25	--	25	809
Hocking Valley	--	--	--	--	13	53	82	38	2	4	30	91	***	--	313	3	--	--	3	316
Illinois Central	11	35	121	190	372	556	419	501	614	658	615	597	439	310	5438	25	126	204	355	5793
Ind. Harbor Belt	--	--	--	--	--	1	3	3	0	0	0	0	0	0	7	--	--	--	--	7
L. & H. R.	--	--	--	1	--	4	4	16	33	10	7	8	3	11	97	--	--	--	--	97
L. & N. E.	--	--	--	--	--	32	0	0	0	0	1	0	0	6	39	--	--	--	--	39
Lehigh Valley	--	--	--	--	57	89	113	92	75	75	55	60	39	22	677	--	--	78	78	755
Long Island	--	--	--	2	8	7	11	2	3	6	(See	P.R.	R.)	--	39	--	--	--	--	39

L. A. & S. L.	--	--	--	--	--	--	1	7	12	36	39	32	40	46	216	2	--	--	2	218
L. & N.	474	9	17	33	43	77	90	75	141	295	374	456	285	268	2637	101	165	--	266	2903
Mich. Cent.	--	--	--	--	--	2	5	11	13	10	8	15	18	20	102	--	--	--	--	102
M. K. T.	--	--	--	2	11	13	17	29	26	33	33	30	31	32	257	10	12	29	51	308
Mo. Pac.	--	--	--	--	2	8	--	--	--	--	--	--	--	--	10	--	--	--	--	10
M. & O.	--	--	--	--	--	--	--	--	18	30	59	18	26	32	183	4	--	--	4	187
N. C. & St. L.	10	--	1	2	2	8	5	7	3	15	15	34	22	50	174	--	2	--	2	176
N. Y. C. (East)	415	84	88	93	136	107	126	165	233	257	295	300	209	183	2681	27	63	44	134	2815
N. Y. C. (West)	--	--	1	18	37	16	31	62	49	44	34	54	38	50	434	--	21	10	31	465
N. Y. C. & St. L.	--	--	--	--	--	2	--	--	--	--	--	--	--	--	2	--	--	--	--	2
N. Y., N. H. & H.	--	--	--	--	12	28	26	57	63	34	27	51	40	25	363	17	67	159	243	606
N. Y. O. & W.	--	--	--	--	--	--	--	--	--	59	62	63	60	48	292	--	--	1	1	293
N. & W.	--	--	--	--	3	17	45	29	18	16	18	25	43	41	255	--	20	--	20	275
N. P.	--	--	--	--	42	39	120	161	152	184	166	160	131	171	1326	48	--	--	48	1374
Pennsylvania	2244	1114	1129	1104	904	649	501	785	868	741	574	584	572	426	12195	--	192	378	570	12765
Reading	--	--	--	--	52	112	107	91	36	42	39	53	57	100	689	--	--	--	--	689
R. F. & P.	--	--	--	--	--	--	--	--	0	0	0	1	0	1	2	3	--	--	3	5
Rutland	--	--	--	--	--	--	--	3	2	1	0	2	3	1	12	--	--	--	--	12
Sou. Pac.	57	9	6	130	118	143	175	243	335	397	530	500	458	331	3432	--	131	251	382	3814
Southern Ry.	--	--	--	--	--	24	6	13	51	123	191	205	201	183	997	--	--	--	--	997
Tem. & No. Ont.	--	--	--	--	--	--	--	--	--	0	0	0	0	0	0	--	--	--	--	0
Union Pacific	--	--	--	36	262	557	498	473	356	289	341	406	457	446	4121	32	--	137	169	4290
Virginian	--	--	--	--	--	--	--	--	--	--	10	12	7	24	53	--	--	--	--	53
West. Maryland	--	--	--	--	--	--	--	65	111	164	212	57	255	148	1012	--	--	--	--	1012
Al Roads	3847	1545	1850	2149	2584	3382	3257	4136	4596	4993	5458	5760	5257	4795	53609	478	1454	2686	4618	58227

* Data given for 1930 covers 11 months from February 1st to December 31st. Prior to 1930 each year's data covers 12 months from February 1st. Subsequent to 1930 each year's data covers 12 months from January 1st.

** Detection methods first used to any extent in 1929. The 1930 column includes detected failures on the N. & W. not previously reported as such.

*** Included in C. & O. after 1929.

TABLE 2

ACCUMULATED TRANSVERSE FISSURE FAILURES REPORTED TO DEC. 31, 1931 BY YEAR ROLLED AND BY MILL

(Includes fissured rails detected before actual failure in track).

Years Rolled	*Unknown*			*Algoma*			*Saucon (Bethlehem)*			*Cambria (Bethlehem)*			*Edgar Thomson (Carnegie)*			*Minnequa (Colorado)*			*Dominion*			*Krupp (German)*		
	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total
Unk.	59	3	62	10	0	10	33	8	41	39	2	41	35	5	40	35	0	35	2	0	2	--	--	--
1889	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1890	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1891	--	--	--	--	--	--	--	--	--	--	--	--	1	0	1	--	--	--	--	--	--	--	--	--
1892	--	--	--	--	--	--	--	--	--	2	0	2	--	--	--	--	--	--	--	--	--	--	--	--
1893	--	--	--	--	--	--	--	1	1	1	0	1	--	--	--	--	--	--	--	--	--	--	--	--
1894	--	--	--	--	--	--	--	--	--	6	0	6	--	--	--	--	--	--	--	--	--	--	--	--
1895	--	--	--	--	--	--	--	--	--	5	0	5	1	0	1	--	--	--	--	--	--	--	--	--
1896	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1897	--	--	--	--	--	--	--	--	--	10	0	10	5	0	5	--	--	--	--	--	--	--	--	--
1898	--	--	--	--	--	--	--	2	2	16	1	17	4	0	4	--	--	--	--	--	--	--	--	--
1899	--	--	--	--	--	--	--	--	--	14	0	14	7	0	7	--	--	--	--	--	--	--	--	--
1900	--	--	--	--	--	--	--	--	--	15	0	15	7	1	8	--	--	--	--	--	--	--	--	--
1901	--	--	--	--	--	--	--	--	--	26	0	26	17	0	17	--	--	--	--	--	--	--	--	--
1902	2	0	2	--	--	--	2	0	2	62	0	62	35	2	37	1	0	1	--	--	--	--	--	--
1903	1	0	1	--	--	--	--	--	--	58	0	58	66	1	67	--	--	--	--	--	--	--	--	--
1904	6	0	6	--	--	--	--	--	--	26	1	27	40	0	40	1	0	1	--	--	--	--	--	--
1905	2	1	3	6	2	8	--	--	--	30	0	30	36	2	38	--	--	--	--	--	--	--	--	--
1906	1	1	1	--	--	--	2	1	3	67	0	67	44	0	44	--	1	1	9	0	9	--	--	--
1907	--	--	--	2	0	2	10	0	10	70	0	70	29	1	30	2	0	2	--	--	--	--	--	--
1908	--	--	--	5	0	5	222	9	231	14	0	14	--	--	--	1	0	1	77	10	87	--	--	--
1909	--	--	--	5	1	6	1398	69	1467	75	0	75	34	3	37	3	0	3	12	0	12	--	--	--
1910	10	4	14	9	2	11	696	34	730	111	8	119	22	0	22	379	16	395	--	--	--	--	--	--
1911	--	2	2	11	2	13	933	40	973	351	2	353	54	3	57	355	27	382	--	--	--	--	--	--
1912	8	6	14	7	0	7	142	10	152	622	29	651	61	3	64	75	2	77	55	2	57	--	--	--
1913	6	17	23	6	1	7	310	16	326	530	38	568	69	8	77	40	1	41	4	0	4	--	--	--
1914	2	0	2	28	3	31	144	2	146	329	14	343	36	2	38	80	7	87	9	0	9	--	--	--

1915	2	0	2	461	17	478	289	27	316	127	2	129	44	4	48	185	7	192	--	--	--	--	--	--
1916	1	0	1	101	8	109	363	14	377	91	2	93	80	5	85	396	43	439	--	--	--	--	--	--
1917	4	0	4	6	0	6	257	7	264	152	1	153	64	4	68	427	71	498	--	--	--	--	--	--
1918	2	0	2	384	20	404	84	7	91	81	6	87	71	2	73	73	11	84	74	9	83	--	--	--
1919	1	0	1	369	23	392	247	13	260	9	2	11	23	1	24	37	8	45	50	4	54	--	--	--
1920	--	--	--	83	3	86	66	7	73	63	1	64	80	9	89	260	84	344	--	--	--	--	--	--
1921	1	0	1	16	33	49	176	11	187	159	8	167	111	10	121	117	22	139	2	0	2	--	--	--
1922	--	--	--	50	113	163	95	27	122	71	7	78	176	9	185	33	6	39	--	--	--	--	--	--
1923	96	0	96	76	74	150	--	--	--	49	1	50	122	22	144	40	10	50	--	--	--	--	--	--
1924	66	0	66	55	98	153	--	--	--	--	--	--	119	20	139	32	8	40	--	--	--	--	--	--
1925	55	0	55	2	5	7	--	--	--	--	--	--	157	35	192	29	10	39	1	4	5	--	--	--
1926	22	0	22	2	1	3	--	--	--	--	--	--	262	77	339	13	6	19	4	2	6	3	1	4
1927	25	2	27	--	17	17	--	--	--	--	--	--	189	57	246	6	3	9	--	--	--	--	--	--
1928	1	0	1	5	23	28	--	--	--	--	--	--	46	43	89	1	5	6	--	--	--	--	--	--
1929	--	--	--	--	--	--	--	--	--	--	--	--	8	22	30	--	--	--	1	0	1	--	--	--
1930	--	--	--	--	--	--	--	--	--	--	--	--	1	4	5	--	--	--	--	--	--	--	--	--
1931	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Totals	373	36	409	1699	446	2145	5469	305	5774	3281	125	3406	2156	355	2511	2621	348	2969	300	31	331	3	1	4

TABLE 2—Continued

ACCUMULATED TRANSVERSE FISSURE FAILURES REPORTED TO DEC. 31, 1931 BY YEAR ROLLED AND BY MILL

(Includes fissured rails detected before actual failure in track).

Year Rolled	*Gary** *(Illinois)*			*Inland* *(Inland)*			*Lackawanna*** *(Bethlehem)*			*Lorain*			*Maryland* *(Bethlehem)*			*Steelton* *(Bethlehem)*			*Ensley* *(Tennessee)*			*All Mills*		
	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total	Prior	1931	Total
Unk.	152	4	156	3	0	3	23	4	27	--	--	--	11	2	13	7	4	11	126	17	143	535	49	584
1889	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	0	2	--	--	--	2	0	2
1890	--	--	--	--	--	--	2	0	2	--	--	--	1	0	1	5	0	5	--	--	--	8	0	8
1891	--	--	--	--	--	--	4	0	4	--	--	--	--	--	--	3	0	3	--	--	--	8	0	8
1892	--	--	--	--	--	--	--	--	--	--	--	--	1	0	1	2	0	2	--	--	--	5	0	5
1893	--	--	--	--	--	--	--	--	--	--	--	--	4	0	4	--	--	--	--	--	--	5	1	6
1894	--	--	--	--	--	--	--	--	--	--	--	--	1	0	1	4	0	4	--	--	--	11	0	11
1895	--	--	--	--	--	--	1	0	1	--	--	--	--	--	--	2	0	2	--	--	--	9	0	9
1896	2	0	2	--	--	--	6	0	6	--	--	--	1	0	1	3	1	4	1	0	1	13	1	14
1897	--	--	--	--	--	--	9	0	9	--	--	--	1	0	1	7	0	7	--	--	--	32	0	32
1898	--	--	--	--	--	--	24	12	36	--	--	--	2	0	2	8	0	8	--	--	--	54	15	69
1899	--	--	--	--	--	--	13	0	13	--	--	--	3	0	3	18	0	18	--	--	--	55	0	55
1900	2	0	2	--	--	--	--	--	--	--	--	--	6	0	6	11	0	11	--	--	--	41	1	42
1901	2	0	2	--	--	--	23	0	23	--	--	--	13	1	14	--	--	--	--	--	--	81	1	82
1902	1	0	1	--	--	--	4	0	4	3	0	3	33	0	33	--	--	--	--	--	--	143	2	145
1903	1	1	2	--	--	--	3	0	3	--	--	--	62	1	63	--	--	--	27	0	27	218	3	221
1904	4	0	4	--	--	--	87	5	92	--	--	--	26	1	27	--	--	--	199	0	199	389	7	396
1905	6	0	6	--	--	--	15	1	16	3	0	3	30	2	32	5	0	5	325	0	325	458	8	466
1906	4	0	4	--	--	--	6	0	6	5	0	5	53	1	54	2	0	2	52	0	52	245	4	249
1907	23	0	23	--	--	--	26	0	26	--	--	--	77	0	77	--	--	--	60	2	62	299	3	302
1908	8	1	9	--	--	--	8	0	8	1	0	1	2	1	3	3	0	3	32	0	32	373	21	394
1909	823	63	886	--	--	--	73	6	79	--	--	--	69	2	71	110	1	111	6	0	6	2608	145	2753
1910	2228	127	2355	--	--	--	229	10	239	--	--	--	115	3	118	114	10	124	147	8	155	4060	222	4282
1911	252	18	270	--	--	--	347	7	354	--	--	--	226	6	232	118	8	126	164	6	170	2811	121	2932
1912	1408	87	1495	--	--	--	850	19	869	--	--	--	187	9	196	92	11	103	117	4	121	3624	182	3806
1913	1438	76	1514	--	--	--	875	61	936	1	0	1	451	31	482	106	17	123	124	7	131	3960	273	4233
1914	371	39	410	--	--	--	729	21	750	--	--	--	141	4	145	111	2	113	205	15	220	2185	109	2294

1915	561	52	613	--	--	--	371	36	407	--	--	--	483	73	556	149	5	154	80	6	86	2752	229	2981
1916	771	104	875	--	--	--	117	12	129	--	--	--	474	45	519	32	1	33	247	8	255	2673	242	2915
1917	2029	288	2317	--	--	--	140	8	148	--	--	--	755	44	799	6	1	7	206	26	232	4046	450	4496
1918	543	85	628	--	--	--	129	2	131	--	--	--	97	7	104	14	1	15	356	28	384	1908	178	2086
1919	1109	185	1294	--	--	--	92	12	104	--	--	--	61	7	68	102	12	114	466	78	544	2566	345	2911
1920	611	83	694	--	--	--	174	19	193	--	--	--	--	1	1	159	12	171	189	18	207	1685	237	1922
1921	456	124	580	--	--	--	148	11	159	--	--	--	2	1	3	245	31	276	156	62	218	1589	313	1902
1922	190	50	240	173	35	208	152	24	176	--	--	--	5	1	6	65	20	85	340	74	414	1350	366	1716
1923	502	144	646	78	28	106	454	54	508	--	--	--	3	4	7	112	22	134	337	59	396	1869	418	2287
1924	271	114	385	66	50	116	145	33	178	--	--	--	6	4	10	200	61	261	506	147	653	1466	535	2001
1925	216	88	304	84	17	101	249	84	333	--	--	--	128	47	175	213	44	257	739	157	896	1873	491	2364
1926	232	126	358	132	41	173	221	134	355	--	--	--	131	55	186	204	64	268	854	141	995	2080	648	2728
1927	148	64	212	11	11	22	236	91	327	--	--	--	246	140	386	209	50	259	559	101	660	1629	536	2165
1928	14	15	29	3	8	11	91	23	114	--	--	--	118	95	213	174	85	259	69	25	94	522	322	844
1929	8	7	15	6	5	11	54	24	78	--	--	--	223	626	849	104	69	173	69	47	116	473	800	1273
1930	5	11	16	--	1	1	--	--	--	--	--	--	1	19	20	25	132	157	1	4	5	33	171	204
1931	--	1	1	--	--	--	--	--	--	--	--	--	--	12	12	--	19	19	--	--	--	--	32	32
Totals	143.1	1957	16348	556	196	752	6130	713	6843	13	0	13	4249	1245	5494	2746	683	3429	6759	1040	7799	50746	7481	58227

* Includes South Works prior to 1920.
** Prior to 1903 was Scranton Mill of Lackawanna Iron & Steel Co.

TABLE 3

AVERAGE TRANSVERSE FISSURE FAILURE RATES ON SELECTED ROADS PER 100 ORIGINAL TRACK MILES PER YEAR FROM YEAR ROLLED TO 12/31/31, BY MILL AND YEAR ROLLED

(Includes fissured rails detected before actual failure in track)

Year Rolled	E. Thom (Carn.)	Ensley Tenn.)	Gary (Ill.)	Inl. (Inl.)	Lack. (Beth.)	Mary. (Beth.)	Minn. (Colo.)	Stltn. (Beth.)	All Mills
1924	2.09	8.16	3.61	3.45	3.45	0.71	0.66	3.87	3.87
1925	2.63	11.82	2.51	2.06	6.80	6.28	0.43	3.98	4.74
1926	5.41	14.03	3.25	3.86	7.20	38.00	0.47	7.73	6.56
1927	3.98	15.60	2.64	2.00	12.48	43.00	0.24	9.89	7.08
1928	2.81	3.51	4.86	0.62	11.37	27.25	0.26	12.93	4.42
Ave.	3.41	11.17	2.71	2.05	7.49	20.54	0.43	6.38	5.31

FIG. 2—Average Failure Rates Classified by Mills (Includes fissured rails detected before actual failure in track)

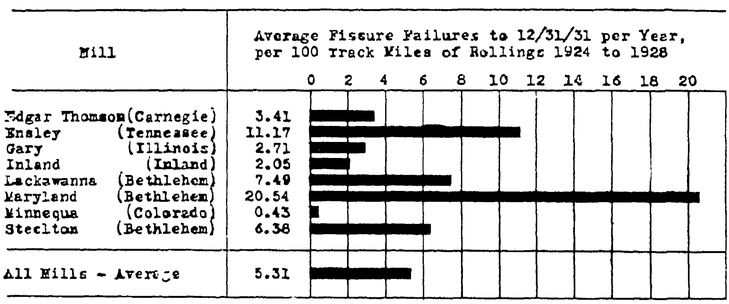
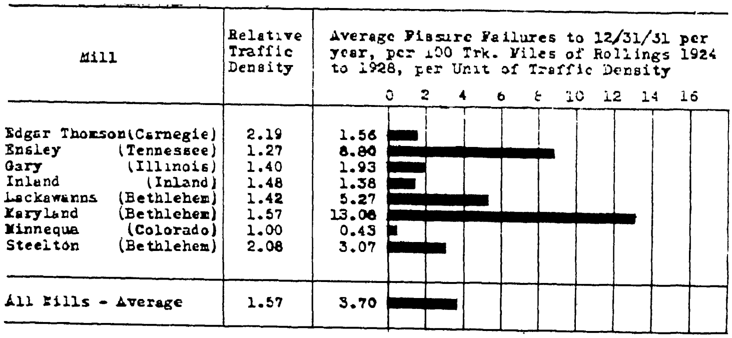


FIG. 3—Average Failure Rates by Mills Altered by Traffic Density Factors (Includes fissured rails detected before actual failure in track)



Appendix C-3

(3) OPERATING RESULTS OF THE A.R.A. RAIL FISSURE DETECTOR CAR

By W. C. Barnes, Engineer of Tests, Rail Committee

In November, 1932, the A.R.A. Detector Car successfully completed its fourth year of operation under the direction of the Rail Committee. Owing to the constant demand on the part of the railroads for testing service the car has not been idle a single day for lack of business since the start of leasing service in November 1928, the only dead time being that required for occasional adjustment and repair and for periodic shopping.

The fact that the car is now largely engaged in repeat business speaks well for the satisfactory service which it is performing for lessee roads. Even in this period of depression, lease commitments are made well in advance of delivery of the car.

In September 1932 an assistant operator was employed, whose services are furnished with the car with no increase in the rental charge of $85.00 per day.

When the car was placed in operation, it was expected that the rental income would retire its original cost of $23,306 in five years. Due to efficient operation and an exceedingly small amount of dead time, the car succeeded in the four years ending November 1932 in writing off its entire first cost ($23,306) as well as the additional $15,000 contributed to the Sperry Company and building up a substantial surplus in addition to maintaining its market value equal to the original cost under the contract.

The matter of improvement in the equipment of the car is receiving constant study and experimentation. Many improvements have been added in the past and will be added in the future. It is expected that the Association will provide a tow car for hauling the detector car as soon as railway business improves.

On November 15, 1932, the car completed its fourth year in leasing service, having tested a total of 16,597 track miles of rail on United States and Canadian roads and having located a total of 1,551 transverse and compound fissure rails and a total of 7,187 defective rails of all types. This corresponds to an average rate of one fissured rail per 10.6 track miles and one defective rail, all types, per 2.3 track miles during the entire four year period. The mileage tested the fourth year ending November 15, 1932 (5,579.8), exceeded the average of the first three years (3,672.5) by 51.9 per cent and at the same time the miles tested per fissured rail decreased from 11.1 to 9.9 and the miles tested per defective rail (all types) from 3.2 to 1.5.

A word of caution is advisable regarding the use of average rates of detection in rating of car performance. The number of defective rails in track depends not upon the test car but upon the track tested, i. e. upon the source of the rails, their age, traffic, roadbed and maintenance, etc., and whether or not said track has been recently tested and defective rails removed. In periodic testing, if the time interval between tests be properly selected, the average rate should be materially reduced.

Attention is called to the transverse fissure statistics in Appendix C-2, Fig. 1, and explanation in the text regarding the effect upon future failures in track of present use of detector cars.

Appendix D

(4) CAUSE AND PREVENTION OF RAIL BATTERING

(10) APPLICATION OF UPSET JOINT BARS ON ALL RAIL BADLY WORN ON FISHING SURFACES

F. M. Graham, Chairman, Sub-Committee; W. J. Backes, W. C. Barnes, W. A. Duff, B. Herman, E. E. Oviatt, W. H. Penfield, R. T. Scholes, J. R. Watt, C. E. Weaver, J. E. Willoughby.

(4) CAUSE AND PREVENTION OF RAIL BATTERING

Your Sub-Committee submits the following progress report.

The study of this subject has been continued and tests of the heat treating of rail ends have been kept under observation to determine the relative amount of batter occurring on treated and untreated joints. The heat treating of rail ends is being tried on several railroads. Various methods of applying the heat treatment are being developed and tried.

The results so far indicate that the heat treating of rail ends when properly applied will materially retard rail end batter and the Committee believes that definite progress is being made.

The study and development of this subject will be continued.

(10) APPLICATION OF UPSET JOINT BARS ON ALL RAIL BADLY WORN ON FISHING SURFACES

Your Sub-Committee reports progress on this subject.

Appendix E

(5) ECONOMIC VALUE OF DIFFERENT SIZES OF RAIL

J. M. Farrin, Chairman, Sub-Committee; Lem Adams, J. B. Baker, W. C. Barnes, F. L. C. Bond, R. Faries, C. R. Harding, C. W. Johns, H. C. Mann, G. J. Ray, A. N. Reece, H. R. Thomas, W. P. Wiltsee.

It was the intention of the Sub-Committee to make final report on this assignment this year but as the subject-matter could not be assembled sufficiently early to enable thorough study and reconciliation of controversial points to be made by the Committee as a whole, your Sub-Committee can only report progress with the recommendation that the assignment be continued.

Appendix F-1

(6) SPECIFICATIONS FOR SPRING WASHERS, COLLABORATING WITH COMMITTEE V—TRACK

(9) RELATIVE MERITS OF RAIL SECTIONS HEAVIER THAN 100 LB. PER YARD FROM STANDPOINT OF ECONOMICAL DISTRIBUTION OF METAL AND STRENGTH

(11) RAIL LENGTHS IN EXCESS OF 39 FEET

Wm. Michel, Chairman, Sub-Committee; Lem Adams, W. C. Barnes, C. B. Bronson, C. T. Dike, F. M. Graham, G. W. Harris, B. Herman, J. E. King, E. E. Oviatt, A. N. Reece, R. T. Scholes, J. E. Willoughby, J. G. Wishart.

(6) SPECIFICATIONS FOR SPRING WASHERS

Your Sub-Committee has prepared the following specifications which are recommended for use by those who purchase spring washers. This recommendation of these specifications, however, does not imply any recommendation for or against the use of spring washers which is a matter outside of the Committee assignment.

SPECIFICATIONS FOR SPRING WASHERS

General Scope

1. These specifications prescribe the physical properties intended for the material of the spring washers purchased and state in detail the method of testing for providing their fulfillment.

Material

2. Material for spring washers shall be of steel, manufactured by the Electric Furnace, Open-Hearth or Crucible Process.

Physical Requirements

Method of Testing

3. Test specimens shall be interposed between the platens of a compression machine of approved design, equipped with a deflection recorder calibrated to .001 of an inch and located so that readings are recorded from approximately the center of the platens, and shall be subjected to the preliminary load of 20,000 pounds three successive times. The washer each time being completely released to its free height.

Mechanical Strength and Ductility

4. After application of the preliminary loads, the washer shall again be compressed to test load in Column 2 and the load shall be released by opening the platens through the prescribed distance, Column 3, for respective sizes of spring washers for bolts in Column 1. A reactive spring pressure of not less than the limits of the loads in Column 4 shall then be required.

Spring Washer for Bolt Diameter in Inches	Applied Load Pounds	Platens Released from Loads by Distances in Inches	Reactive Spring Pressure in Pounds Minimum
1	2	3	4
¾″	20,000	.025	2500
⅞″	20,000	.028	2500
1″	20,000	.031	2800
1⅛″	20,000	.036	3000
1¼″	20,000	.036	3000
1⅜″	20,000	.041	3200
1½″	20,000	.041	3200

Note:—Distances prescribed in Column 3 are approximately equivalent to one-fourth turn of the nut.

5. Ductility shall be determined by twisting one end of a finished spring washer through 90 degrees without sign of fracture, while the other end is held securely in a vise, as follows:

(a) Fasten one-fourth of the length of the coil from one end between the jaws of a vise.

(b) Grip one-fourth of the length of the coil from the other end between the jaws of a wrench.

(c) Rotate the wrench, thus causing the end of the coil to describe a circle about the middle point of the coil as a center so that open ends of washer shall pass each other.

6. Spring washers shall be heat treated by oil quenching and tempering.

Proportion of Tests

7. Tests shall be made of three specimens selected by the inspector at random from each lot of 15,000 finished spring washers for bolts less than 1″ in diameter or from each lot of 10,000 finished spring washers for bolts 1″ or more in diameter. The three test specimens from each lot or fraction thereof shall be tested for reactive pressure and ductility, and if all specimens meet the specification requirements the lot will be accepted.

If one of the three test specimens should fail, two more specimens shall be selected from the same lot and if both meet the specification requirements the lot will be accepted. If one or both fail the lot will be rejected.

If two of the first three specimens selected from a lot should fail, all the washers from that lot shall be rejected.

Reheat Treatment

8. If the results of the physical tests do not conform to the requirements specified, the manufacturer may reheat-treat each lot, but not more than three additional times, unless authorized by the purchaser, and retests shall be made as specified in Section 7.

No lot which has failed to pass the tests shall be offered for further test until after the spring washers in that lot have been retreated.

Accuracy of Manufacture

Uniformity of Stock

9. Uniformity in size of steel stock used in making spring washers and the dimensions around which the spiral is coiled are desirable. In cross-section the faces of the finished spring washer which bear against the joint bar and the nut must be parallel.

Permanent Set

10. Previous to offering any lot of spring washers for inspection, each individual piece shall have been subjected as a part of the routine manufacturing process to shock or pressure sufficient to cause permanent set and any individual pieces defective through seams, quenching cracks, etc., shall be discarded.

Finish

11. All finished pieces must be clean, smooth, without burrs or rough edges, of uniform size, with well-shaped symmetrical coil and cross-section, free from injurious mechanical defects, and be finished in a first-class, workmanlike manner.

Identification

Packing

12. The finished spring washers shall be packed in securely hooped kegs or well fastened boxes. Containers shall be left open until the inspection is completed.

Branding

13. Identification will be by the manufacturer's marks.
(a) Spring washers shall be individually marked for identification.
(b) Containers shall be marked as follows:
1. Name of Manufacturer.
2. Size of Spring Washer (Bolt size over thread, width and thickness).
3. Number of Spring Washers.

Acceptance Requirements

Defect Found After Delivery

14. Spring washers to the extent of five per cent, or more of the order which show injurious defects subsequent to their acceptance at the place of manufacture or sale will be rejected and returned to the manufacturer who must pay the freight charges both ways, and replace the defective spring washers with new ones, fulfilling the requirements of the specifications.

Place of Tests

15. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the mill, and shall be made at the place of the manufacturer prior to shipment.

Access to Works

16. Inspectors representing the purchaser shall have free entry to the works of the manufacturers at all times while the contract is being executed, and shall have all reasonable facilities afforded them by the manufacturer to satisfy them that the spring washers are furnished in accordance with the terms of these specifications.

Recommendation

(1) That the Specifications for Spring Washers be adopted as recommended practice and published in the Manual.

Appendix F-2

(9) RELATIVE MERITS OF RAIL SECTIONS HEAVIER THAN 100 LB. PER YARD FROM THE STANDPOINT OF ECONOMICAL DISTRIBUTION OF METAL AND STRENGTH

In its 1915 report, your Committee presented sections for rails weighing 100, 110, 120, 130 and 140 lb. per yard, with the comment that, "in arriving at the sections submitted, there had been some compromises, ... in our efforts to reach a recommendation for a single type of standard".

The 100, 110 and 120 lb. sections were adopted as standard by the Association at the Convention of that year. Five years later, in 1920, the 130 and 140 lb. sections, presented in 1915, were adopted. In 1924 the 150 lb. section was adopted, far in advance of any demand for rail of so heavy a section.

A number of railroads have used the 100, 110 and 130 lb. sections and a considerable tonnage is in track. No rail has ever been rolled to the 120, 140 and 150 lb. sections.

At the time these sections were first submitted in 1915, there was controversy between those who advocated a rail with a deep head and those who favored a rail with a shallow head. The use of the deep headed rail, permitted a greater head wear, but sacrificed height and consequently vertical strength and stiffness of the rail, as well as of the joint bar. The P.S. sections of the Pennsylvania Railroad were representative of this type. The advantages, to be gained by the use of the shallow headed rail, are offset only by less area of head offered for wear. The Dudley sections of the New York Central were representative of this type.

In order to obtain an agreement on a rail section, it was, at that time, necessary to adopt a compromise between these two types. Like most compromises, this one failed as it did not produce the best that could be obtained from a given amount of metal. As might have been expected, neither the Pennsylvania Railroad nor the New York Central, which roads use the largest tonnages of rail of any of the railroads, have used these sections and to that extent they failed to become standard.

The considerable tonnage of rail rolled to the 110 and 130 lb. R.E. sections has been in use a sufficient length of time to demonstrate that the sections are not altogether satisfactory. A study of the details of the dimensions and proportions of the sections indicate that a more economical distribution of the metal, with resulting increase in strength, may be obtained. To this end, your Committee undertook the study of this subject concentrating attention on the 110 and 130 lb. sections. The Sub-Committee having this in charge submitted several tentative sections for these two weights of rail.

Your Committee defers action on the 110 lb. section and reports as follows on the 130 lb. section:

In designing a rail section the following principles are applied:

(1) The sections should be so designed as to give the maximum vertical and horizontal stiffness and strength for the weight of metal.

(2) The proportion of base to height should be sufficient to insure stability against overturning.

(3) The distribution of metal between the head, web and base should be such as will minimize the setting up of internal strains while cooling.

The 130 lb. tentative sections submitted by the Sub-Committee embodied these principles. However, when they were compared with the Dudley 130 lb. section and the Pennsylvania 131 lb. section the differences were so slight as to be measured by small fractions of an inch.

The Pennsylvania 131 lb. section is the result of a very exhaustive study, a description of which is given in Exhibit 1, and service in heavy tonnage tracks of a year and a half has demonstrated the superiority of its design.

As there was so little difference between this Pennsylvania 131 lb. section, the Dudley 130 lb. section of which no rail has been rolled, and the section proposed by the Sub-Committee, the Committee saw the opportunity of reaching an agreement on a rail section that represented the best that could be obtained from the weight of metal, a section that already was in use by one of the largest users of rail and one which could reasonably be expected to become a universally adopted standard. This would meet the present day demand for standardization and the attendant economies resulting from the elimination of a large number of slightly varying designs.

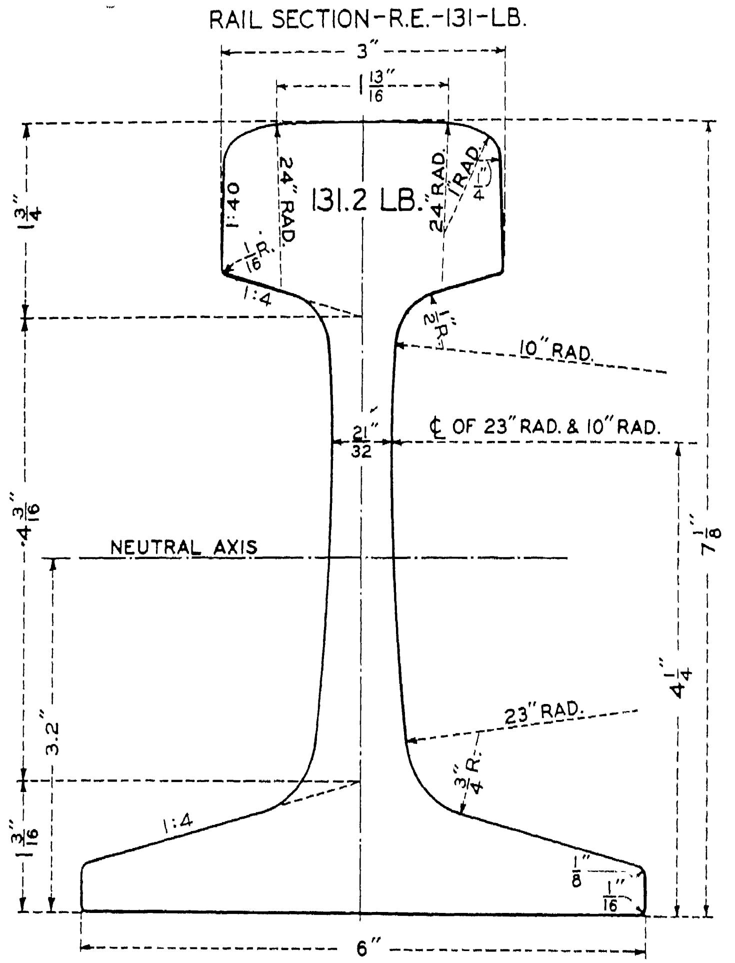
Recommendations

(1) Your Committee therefore unanimously agrees upon the Pennsylvania 131 lb. section shown on Fig. 1 and recommends its adoption and publication in the Manual as the standard 131 lb. R.E. rail section in place of the present 130 lb. R.E. section shown on page 145 of the 1929 Manual, which section it is recommended be withdrawn from the Manual.

(2) As the 120, 140 and 150 lb. R.E. rail sections have never been used and as the tendency is to increase the weight of rail used by increments of 20 pounds instead of 10 pounds it is recommended that these sections shown on pages 144, 146 and 147 of the 1929 Manual be withdrawn.

(3) In connection with the above recommendations it is recommended that the Table headed "Application of recommended rail drilling to standard rail sections," page 162 of the 1929 Manual, be revised to eliminate the drilling for the 120, 130 and 140 lb. R.E. sections.

(4) It is further recommended that the "Height of bolt hole above base of rail" of 3¼" for the 131 lb. R.E. rail section be added to the table referred to in Recommendation 3.



AREA: HEAD =	4.57 SQ. IN.	35 %	
WEB =	3.43 "	"	27 %
BASE =	4.86 "	"	38 %
TOTAL =	12.86 "	"	100 %

MOMENT OF INERTIA	89
SECTION MODULUS, HEAD	23
" " BASE	27
RATIO M. I. TO AREA	7
RATIO SEC. MOD TO AREA	2
RATIO HEIGHT TO BASE	1 19
RATIO BASE TO HEIGHT	0.84

Fig. 1

Exhibit 1

THE DESIGN OF A RAIL SECTION

At a meeting of the Rail Committee a number of tentative sections were submitted by the Sub-Committee. During the discussion that followed the question was raised as to the various factors entering into the problem of designing a rail section. In this connection Robert Faries, Assistant Chief Engineer Maintenance, Pennsylvania Railroad, was asked if he would favor the Committee with the reasons why his road adopted its new sections. Mr. Faries very graciously did this in a letter, copies of which were sent to the members of the Committee. For information of the members this letter is given herewith.

November 19, 1932.

Mr. Earl Stimson, Chairman,
Rail Committee—A.R.E.A.
Baltimore, Md.

Dear Sir:

In connection with the discussion of Subject No. 9, Rail Sections, at the Rail Committee meeting, October 20, 1932, Chicago, it was suggested that the Committee should have the benefit of the reasons which led The Pennsylvania Railroad to adopt its new sections.

Recognition of the fact that the 130 lb. P.S. rail was not entirely satisfactory for present and possible future axle loads, service and speeds, was the primary reason that lead to the design and adoption of the new rail sections. It was desired to provide a rail with more vertical stiffness and strength, better wearing shape of head and a height of fishing space which would allow of the use of better joints. Comparative results obtained from an extensive test of the 127 lb. Dudley section rail in our tracks indicated that a change in our rail section would be advantageous.

The design of these new sections was governed by certain general principles and facts developed by research, and by experience, which we have set forth in the following:

General Principles

Sections should approach uniform rate of cooling to avoid setting up strains in head, web and base.

Large masses of metal should be avoided in order to prevent internal strains in any of the parts due to difference of temperature within the mass while cooling.

The section should provide maximum stiffness for weight, both vertically and laterally.

Proportion of base to height should be sufficient to hold rail stable under the forces set up by a locomotive starting to overturn.

A summary of investigations relative to the stability against overturning of 130 lb. and 152 lb. P.S. rails, collected from six different sources working independently, is as follows:

1. "The relative stability, of two rails, against overturning about the outside edge of the base is not determined by the ratio $\frac{\text{rail base}}{\text{rail height}}$ but rather by the ratio— $\frac{\text{moment arm of vertical load}}{\text{moment arm of lateral load.}}$

"A consideration of the above comparison seems to justify the conclusion that the 152 lb. rail should possess practically the same amount of stability against overturning as does the 130 lb., but its influence on locomotive lateral oscillations on tangent is unknown.

2. "The 152 lb. rail is not less stable than the 130 lb. rail.

3. "The 152 lb. rail on 152 lb. standard inclined tie plates is more stable than 130 lb. rail on standard (not canted) tie plates, under all conditions.

4. "There is ample factor of safety against overturning of the rail and the stresses in the track fastenings are within safe limits and are no greater than under the heavy steam locomotives moving at present speeds on 130 lb. rail.

5. "The 152 lb. rail has ample overturning stability with the conditions of P electric locomotive at a speed of 100 miles per hour, curvature of 1° 30′, superelevati 5½″ or 6″, and for the K-4-s steam locomotive at a speed of 90 miles per hour.

6. "Both rails are less stable for P-5 (electric) than for K-4-s (steam) locom tives and that the 152 lb. rail canted, is more stable than the 130 lb. rail, not cante for both locomotives, and that the worn rails are less stable than the new rails."

In consideration of the above conclusions it should be borne in mind that tl dimensional ratios of 152 lb. and 131 lb. sections are identical.

The Rail Head

The depth of the head should be such that after its normal life in important tracl it will have sufficient metal to insure sufficient strength for a normal life in secondar tracks.

The width of the head should be maximum, and yet avoid guttering of rails b tires on low side of curves. It is important to provide lateral stiffness in the heac which is obtained by width.

Vertical sides instead of sloping sides give extra lateral stiffness, which is ver necessary for future loads and speeds.

A comparison of the lateral moment of inertia of the tentative 130 lb. R.E A-2, 131 lb. P.S. and 152 lb. P.S. sections with the 130 lb. P.S. section is as follows

Lateral Moment of Inertia

Tentative 130 lb. R.E. Sec. A-2	130 lb. P.S. Section	131 lb. P.S. Section	152 lb. P.S. Section
15.2	13.2	16.1	20.7

In connection with the joint investigation of the U. S. St. Corp. and P.R.R. engineers leading to the adoption of the 131 lb. and 152 lb. P.S. sections, C. G. E Larsson, Chief Consulting Engineer, American Bridge Company, calculated the unit pressure in pounds per square inch on head, with new tires on new rail, and the vertical shear in the head for the above mentioned P.S. sections and 170 lb. section suggested by him, for a hypothetical L-6 electric locomotive with 100,000 lb. axle loads at a speed of 100 miles per hour. These calculations were checked independently by F. M. Graham, Assistant Engineer of Standards. The results are shown in the following table:

Unit Pressure and Vertical Shear

(Assumed 1 deg. Curve with 6″ Superelevation)

	130 lb. P.S.	131 lb. and 152 lb. P.S.			170 lb. Suggested by Mr. Larsson
Radius of Head	12″	24″	36″	40″	Flat
Unit Press. on Head	205,000	158,000	141,000	134,000	81,500
Vertical Shear in Head	39,500	31,100	27,800	26,400	16,500
Dist. of Cen. of Brg. to Cen. of Head	0.6″	0.6″	0.6″	0.67″	0.
Cant of Rail	None	1 in 40	1 in 30	1 in 30	1 in 20

It is apparent that the metal in the head is badly over-stressed, which results in immediate side and end overflow, particularly at the end where symmetrical resistance of the surrounding metal is lost on one side of the area of pressure. This pressure should be distributed over the rail head as much as possible. It becomes so distributed when the rail is worn and contour of worn rail is the contour of the average wheel.

Over-run of metal in center of rail head results in large size chips breaking out due to slight movement vertically between rail ends. Over-run on the fillets at the edge of the rail is not so serious, and while some chipping may develop, it is small and of not much consequence.

While heat treatment and grinding of rail ends, and cutting off overflow, minimizes these difficulties it is better to have a properly shaped wearing surface to start with.

On curves the wearing surface of head has a decided effect upon abrasion from wheel flanges. This is shown in the following table for both tangent and curved track after 1 year 4 months' service (gross tonnage 63,500,000) of 130 lb. P.S. and 131 lb. P.S. rails:

TABLE OF RAIL ABRASION

No. 1 Track—Between Spruce Creek and Tyrone

(Tangent and Curved Track)

Wt. Lb. per Yd.	Mos. of Service	Gross Tons Over Rails (Milns)	Degree of Curve or Tang.	Average Sq. In. of Abrasion							% Wear Based on 100% for 130-lb.
				No. Rails Meas.	Sou. or Low Rail	No. Rails Meas.	Nor. or High Rail	No. Rails Meas.	Hi., Low, Nor. or Sou. Rails	Per 10 Milns. Tons Ov-Rails	
1	2	3	4	5	6	7	8	9	10	11	12
130	16	63.5	4°56′ L 4°47′ H	20	.446	20	.663	40	.554	.087	100
131	16	63.5	5°25′ L 5°28′ H	15	.181	15	.457	30	.319	.050	58
130	16	63.5	Tang.	5	.374	5	.340	10	.357	.056	100
131	16	63.5	Tang.	5	.154	5	.160	10	.157	.025	44

The Web

Maximum fishing section should be provided to give strength to the joint. Short radius fillets, which concentrate stresses, should be avoided.

The web should be so designed that uniform fibre stresses well within the elastic limit of the material will result from application of maximum vertical and lateral loads.

These stresses for the tentative 130 lb. R.E. A-2 and 131 lb. P.S. sections are shown on Fig. 2. The horizontal force of 17,000 lb. was the maximum measured lateral force developed in Claymont tests with electric locomotive at high speeds.

Certain theoretical calculations of web and fillet stresses show quite high stresses under the head, but such calculations are based on conditions away from the rail end and where web failures seldom or never occur. At the rail end conditions are entirely different and a number of web failures occur at this point, but it is our experience that 73 per cent of them are above the base of rail and below neutral axis.

The accumulation of facts outlined above led us to provide a web of conventional design, but somewhat thicker and stronger in the area between neutral axis and the bottom of the web.

The Base

The width of the base is fixed by the accepted H/B ratio, which is the result of conclusions drawn from calculations involving many variables, of which speed, axle load, loading arrangement, position of center of gravity and character of fastenings are representative.

The thickness of the base should be such that the maximum fibre stress is well within the elastic limit.

The experience of the P.R.R. has been that numerous base failures occurred in rails with lighter base section than the 130 lb. P. S., 131 lb. P.S. and 152 lb. P.S. rails.

Comparative Strength

From Professor Talbot's formula, given in the First Progress Report of the Committee on Stresses in Railroad Track, comparative data for different sections of rail can be calculated for simple and supported spans.

Using the calculated data for the rail sections referred to in this report, their comparative strength on the basis of $\frac{I^{3/4}}{C}$ is as follows:

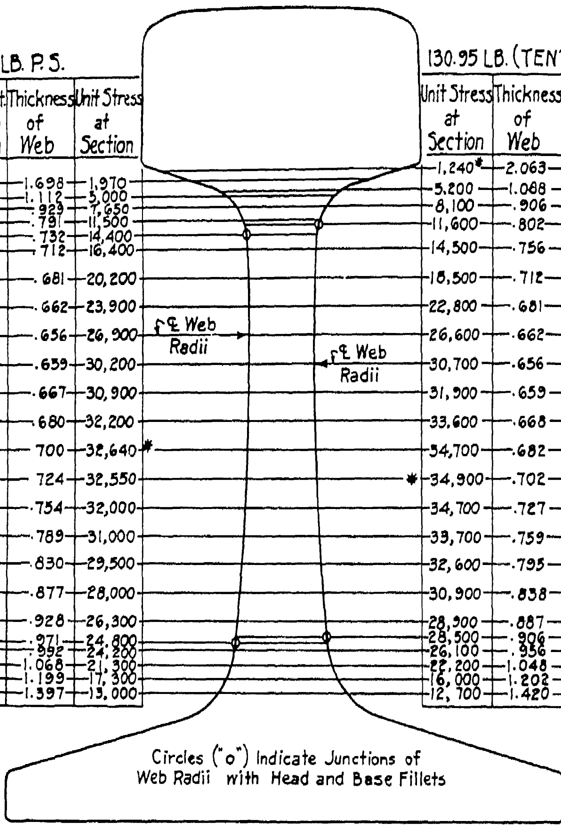
130 lb. P.S. 100.00
Tentative 130 lb. R.E. Sec. A-2..............103.13
131 lb. P.S. 105.38
152 lb. P.S. 121.39

Yours very truly,

(Signed) ROBT. FARIES,
Assistant Chief Engineer—Maintenance.

131 LB. P.S.

Vert. Dist. Load to Section	Thickness of Web	Unit Stress at Section
1.288	1.698	1,970
1.406	1.112	5,000
1.500	.929	7,650
1.625	.791	11,500
1.756	.732	14,400
1.875	.712	16,400
2.125	.681	20,200
2.375	.662	23,900
2.625	.656	26,900
2.875	.659	30,200
3.125	.667	30,900
3.375	.680	32,200
3.625	.700	32,640*
3.875	.724	32,550
4.125	.754	32,000
4.375	.789	31,000
4.625	.830	29,500
4.875	.877	28,000
5.125	.928	26,300
5.309	.971	24,800
5.375	.992	24,200
5.500	1.068	21,300
5.625	1.199	17,300
5.750	1.397	13,000



130.95 LB. (TENT.) A.R.E.A.

Unit Stress at Section	Thickness of Web	Vert. Dist. Load to Section
1,240*	2.063	1.187
5,200	1.088	1.375
8,100	.906	1.500
11,600	.802	1.669
14,500	.756	1.875
18,500	.712	2.125
22,800	.681	2.375
26,600	.662	2.625
30,700	.656	2.875
31,900	.659	3.125
33,600	.668	3.375
34,700	.682	3.625
*34,900	.702	3.875
34,700	.727	4.125
33,700	.759	4.375
32,600	.795	4.625
30,900	.838	4.875
28,900	.887	5.125
28,500	.906	5.265
26,100	.956	5.375
22,200	1.048	5.500
16,000	1.202	5.625
12,700	1.420	5.750

VERTICAL WEB STRESSES IN 131 LB. P.S. AND 130.95 LB. (TENTATIVE) A.R.E.A. RAIL SECTIONS RESULTING FROM SINGLE HORIZONTAL FORCE OF 17,000 LB. ACTING AT A POINT ¼" BELOW TOP OF HEAD OF RAIL.

FIG. 2

Appendix F-3

(11) RAIL LENGTHS IN EXCESS OF 39 FEET

Your Sub-Committee has given considerable study to the matter of desirable length of rails but desires to study further the relative economies of manufacturing and of maintenance before expressing a conclusion as to an alternative recommended practice. It reports progress only for this year and recommends that the subject be continued for further study.

Appendix G

(7) COMPILATION OF INFORMATION OF TESTS OF ALLOY AND OF HEAT-TREATED CARBON STEEL RAILS

(8) PREPARATION OF SPECIFICATIONS FOR INTERMEDIATE MANGANESE STEEL RAIL

J. B. Young, Chairman, Sub-Committee; J. E. Armstrong, W. C. Barnes, E. E. Chapman, W. A. Duff, C. W. Johns, E. E. Oviatt, G. J. Ray, A. N. Reece, R. T. Scholes, C. P. Van Gundy, J. R. Watt.

(7) COMPILATION OF INFORMATION OF TESTS OF ALLOY AND OF HEAT-TREATED CARBON STEEL RAILS

Your Sub-Committee reports that very little additional tonnage of alloy or of heat-treated carbon steel rail has been purchased by the railroads during the past year and that there is little change in the record of failures.

The Sub-Committee reports progress this year.

(8) PREPARATION OF SPECIFICATIONS FOR INTERMEDIATE MANGANESE STEEL RAIL

Last year's report on this subject stated that the largest users of intermediate manganese steel rail were experimenting with compositions differing from those which they had previously purchased and that the preparation of specifications would be deferred until definite knowledge of the most suitable composition is available. This involves service tests. Such information as has since been secured is not sufficient to warrant the preparation of specifications at this time.

The Sub-Committee reports progress.

REPORT OF COMMITTEE IX—GRADE CROSSINGS

J. G. BRENNAN, *Chairman;*
E. L. ANDERSON,
F. D. BATCHELLOR,
H. D. BLAKE,
F. J. BLICKENSDERFER,
H. E. BRINK,
JOHN CARMICHAEL,
C. W. CHARLESON,
S. N. CROWE,
L. B. CURTISS,
A. T. DANVER,
C. A. DAYTON,
A. R. DEWEES,
G. N. EDMONDSON,
C. F. EDWARDS,
H. L. ENGELHARDT,
H. W. FENNO,
L. C. FROHMAN,
P. M. GAULT,
R. C. GOWDY,
J. P. HALLIHAN,
H. A. HAMPTON,
M. V. HOLMES,
A. G. HOLT,
W. M. JAEKLE,
MARO JOHNSON,
R. B. KITTREDGE,
W. B. KNIGHT,
A. E. KORSELL,
W. S. LACHER,
E. R. LEWIS,
G. P. PALMER,
BERNARD BLUM, *Vice-Chairman;*
W. C. PINSCHMIDT,
L. J. RIEGLER,
FRANK RINGER,
C. E. ROBINSON,
H. M. SHEPARD,
W. C. SWARTOUT,
A. H. UTTER,
V. R. WALLING,
R. F. WOOD,
LEROY WYANT,
W. L. YOUNG,
A. M. ZABRISKIE,

Committee.

To the American Railway Engineering Association:

Your Committee on Grade Crossings presents herewith report on the following subjects:

1. Revision of Manual (Appendix A).

(a) Further study of the proper lighting of the base of signals where located in the center of highway. Recommended that the conclusion be adopted by the Association.

(b) Detail plans of "Number-of-Tracks" sign, both painted and with reflector lenses. The recommendation is submitted for adoption by the Association.

(c) Detail plans of the illumination of highway cross-buck signs by means of reflector lenses. Recommended that the detail plans be adopted by the Association as standard.

ADDENDA 1

(a) Specifications covering detail plans (b) and (c) above-mentioned. The recommendation is submitted for adoption by the Association.

(b) Revision of Highway Crossing Sign, illustrated on page 65, A.R.E.A. Bulletin Vol. 33, No. 337, July, 1931. Recommended that the revision be approved by the Association.

2. Economic aspects of grade crossing protection in lieu of grade separation. Recommended that the subject be continued (Appendix B).

3. Laws, regulations and practices governing dimensions and clearances affecting construction, protection, elimination and separation of grades of highway grade crossings. Recommended that the report be received as information (Appendix C).

4. Laws and practices for determining division of cost of highway grade crossing separations. Recommended that the report be received as information (Appendix D).

5. Drainage methods for grade crossing elimination projects and division of cost chargeable thereto. Recommended that the report be received as information (Appendix E).

6. Use of concave street sections for grade separation subways and transition from crown to concave sections. Recommended that the report be received as information (Appendix F).

Bulletin 354, February, 1933.

7. Study and recommend standard specifications for street crossings over railway tracks, both steam and electric, collaborating with Committee I—Roadway, and with the American Society of Municipal Engineers and the American Electric Railway Association (now the American Transit Association). Recommended that the subject be continued (Appendix G).

8. Use of highway crossing plank and substitutes therefor, collaborating with Committees I—Roadway and V—Track. Recommended that the subject be continued and the further recommendation be adopted by the Association (Appendix H).

9. Stock guards—types, uses and necessity. Recommended that the report be received as information (Appendix I).

Respectfully submitted,

THE COMMITTEE ON GRADE CROSSINGS,

J. G. BRENNAN, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

P. M. Gault, Chairman, Sub-Committee; H. D. Blake, Bernard Blum, H. E. Brink, C. A. Dayton, H. L. Engelhardt, H. W. Fenno, M. V. Holmes, Maro Johnson, R. B. Kittredge, E. R. Lewis, G. P. Palmer, W. C. Pinschmidt, Frank Ringer, Leroy Wyant, A. M. Zabriskie.

(a) Further study of the proper lighting of the base of signals where located in the center of highway.

Conclusion

It is the opinion of your Committee that no change should be made in the present standard, which is fully outlined in A.R.E.A. Bulletin Vol. 33, No. 337, July, 1931, and also in Bulletin No. 1 of the Joint Committee on Grade Crossing Protection, A.R.A. Your Committee feels that either of the methods of illumination shown is sufficient.

It is recommended that this conclusion be received by the Association as information and that the Joint Committee on Grade Crossing Protection, A.R.A., be advised of the action taken.

(b) Detail plans of "Number-of-Tracks" sign, both painted and with reflector lenses.

Your Committee has cooperated with the Signal Section, A.R.A., in developing detail plans for the following:

1. Detail plans for the "Number-of-Tracks" sign, both painted and with reflector lenses, identified as A.R.A. Signal Section Detail Drawings Nos. 1644A and 1645A.

2. Detail plans of the crossbuck sign, both painted and with reflector lenses, for use in connection with flashing light or wig-wag signals, identified as A.R.A. Signal Section Detail Drawings Nos. 1640A, 1641A, 1642A and 1643A.

3. Detail plans for the illumination of the "Stop on Red Signal" sign and the "Stop-When-Swinging" sign, by means of reflector lenses, identified as A.R.A. Signal Section Detail Drawings Nos. 1646A and 1648A.

4. Plan of Adapter Clamp and Details for Signs, identified as A.R.A. Signal Section Detail Drawing No. 1647A.

5. Plan of Reflector Crossing Signal Marker, identified as A.R.A. Signal Section Detail Drawing No. 1649A.

6. Plan of Details of Numerals for Track Signs, identified as A.R.A. Signal Section Detail Drawing No. 1650A.

Recommendation

It is the recommendation of your Committee that the above-described drawings be endorsed by the Association as standard, by reference.

(c) Detail plans of the illumination of highway cross-buck signs by means of reflector lenses.

Your Committee, in conjunction with the Signal Section, A.R.A., have developed detail plans for the illumination of this sign, by means of reflector lenses. Two plans showing the details are submitted herewith.

The assembly is not shown mounted. It can be mounted on a wood or concrete pole with the aid of straight bolts or it can be mounted on a pipe mast with the aid of clamp shown on Signal Section Drawing No. 1647A, in the same manner shown for the 90 degree reflector crossbuck.

Recommendation

It is the recommendation of your Committee that the above-described detail plans be adopted by the Association as standard.

Addenda 1

(a) A.R.A. Signal Section Specification Nos. 15633 and 15533.

The above-entitled specifications have been prepared to provide signs of various designs for railroad highway grade crossing protection, as heretofore described by drawings, under (b) and (c). (Exhibit B.)

Recommendation

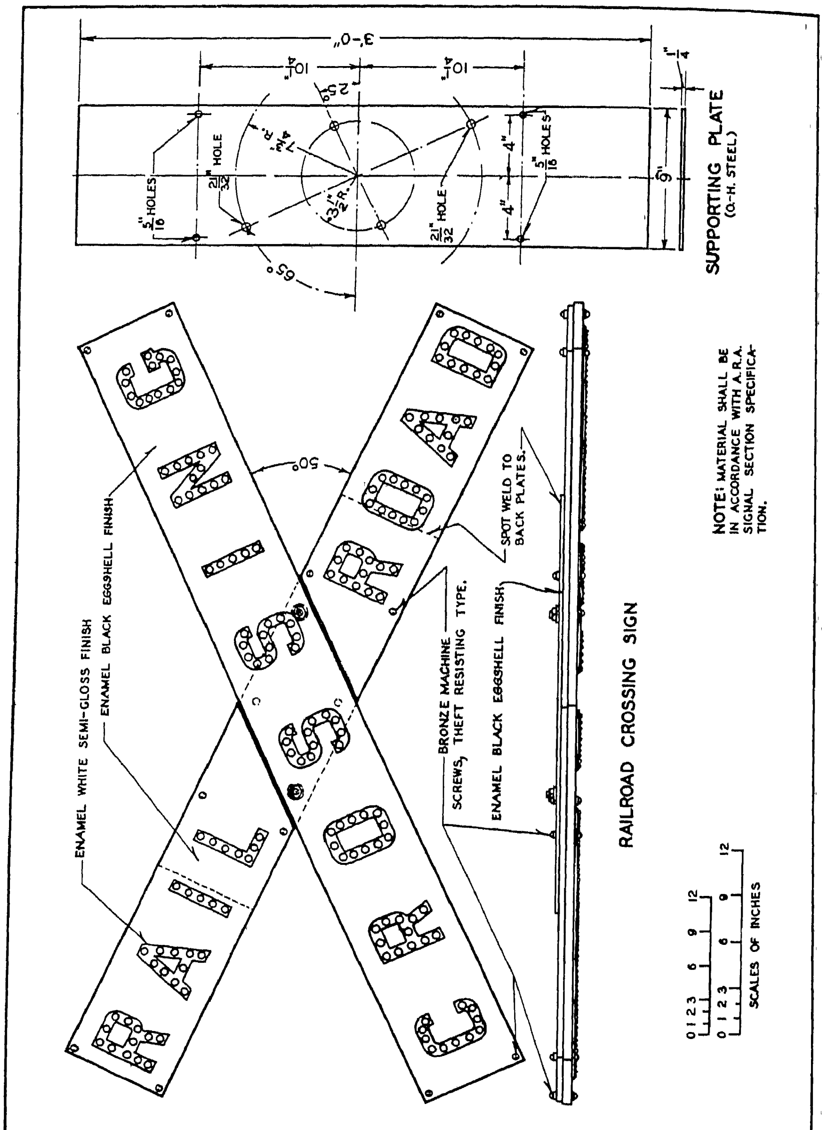
It is the recommendation of your Committee that the above-mentioned specifications be endorsed by the Association as standard, by reference.

(b) Revision of Highway Crossing Sign, illustrated on page 65, A.R.E.A. Bulletin Vol. 33, No. 337, July, 1931, to omit the 50 degree angle shown between the blades.

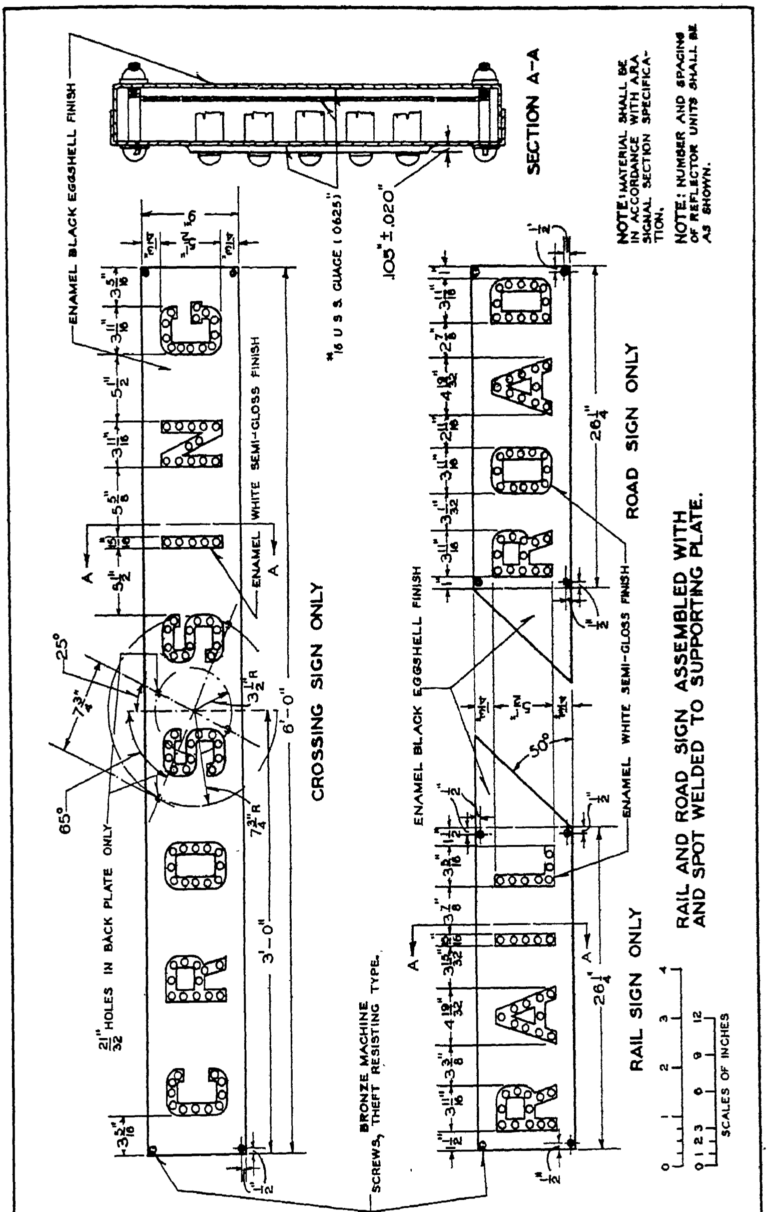
It has been called to the attention of your Committee, that most of the roads throughout the country are using the crossbuck sign and that if the A.R.E.A. Manual could be revised to eliminate the angle between the blades, the practice of the railroads generally would then conform to the A.R.E.A. standard (as revised), excepting in certain states where laws require variation in painting or otherwise.

Recommendation

It is the recommendation of your Committee that the 50-degree angle shown between the blades of the Highway Crossing Sign, be eliminated.



50° REFLECTOR CROSSING SIGN ASSEMBLY



50° REFLECTOR CROSSING SIGN DETAILS

Appendix B

(2) ECONOMIC ASPECTS OF GRADE CROSSING PROTECTION IN LIEU OF GRADE SEPARATION

G. P. Palmer, Chairman, Sub-Committee; S. N. Crowe, L. B. Curtiss, C. A. Dayton, A. R. Dewees, G. N. Edmondson, J. P. Hallihan, W. M. Jaekle, Maro Johnson, R. B. Kittredge, A. E. Korsell, E R. Lewis, Frank Ringer, A. H. Utter, Leroy Wyant.

Considerable time and effort have been devoted to the investigation and study of this subject during the past two years. The broad scope of the subject requires collection of a great amount of statistical and cost data and it has not been possible to reach a definite and final determination to date. Preliminary studies have been developed, involving comparative tables, etc. The information compiled to this time permits only a report of progress being made.

Recommendation

It is the recommendation of your Committee that the subject be continued for further study and report.

Appendix C

(3) LAWS, REGULATIONS AND PRACTICES GOVERNING DIMENSIONS AND CLEARANCES AFFECTING CONSTRUCTION, PROTECTION, ELIMINATION AND SEPARATION OF GRADES OF HIGHWAY GRADE CROSSINGS

W. C. Pinschmidt, Chairman, Sub-Committee; H. D. Blake, H. E. Brink, S. N. Crowe, A. T. Danver, G. N. Edmondson, H. L. Engelhardt, R. B. Kittredge, W. B. Knight, C. E. Robinson, A. H. Utter, W. L. Young.

Information for this assignment was secured by means of a questionnaire which was distributed to the several State Highway Departments of the United States, the District of Columbia, and the Canadian Provinces. Wherever possible, the legal requirements have been indicated in the tabulation, which is submitted herewith.

Recommendation

It is the recommendation of your Committee that the report be received by the Association as information.

Appendix D

(4) LAWS AND PRACTICES FOR DETERMINING DIVISION OF COST OF HIGHWAY GRADE CROSSING SEPARATIONS

M. V. Holmes, Chairman, Sub-Committee; F. D. Batchellor, F. J. Blickensderfer, Bernard Blum, C. W. Charleson, P. M. Gault, R. C. Gowdy, J. P. Hallihan, Maro Johnson, A. E. Korsell, W. S. Lacher, G. P. Palmer, V. R. Walling.

The investigation and study of this assignment has been carried on for the past two years. The Summary of Laws and Practices in each State has been compiled from examination of laws and information obtained from various sources. Report submitted

ALABAMA

Authority is vested in State Highway Commission on grade elimination projects on state roads to compel railroads to pay 50 per cent of cost of portion on right-of-way.

If after due notice from State Highway Commission railway fails or refuses to build structure, Commission may build structure and Attorney-General will sue railroad for 50 per cent of cost of structure on right-of-way.

Cities over 35,000 may require railroads to construct and maintain 100 per cent of grade separation structure.

Public Service Commission has jurisdiction over railroads but has no authority to enforce division of costs.

In two recent cases on state roads the railroads bore 50 per cent of cost of structure but no cost of approaches.

ARIZONA

Corporation Commission has full jurisdiction over all present and future grade crossings including division of costs in elimination projects.

In several recent cases the costs to railroads have been from 25 per cent to 50 per cent and average about 40 per cent.

On new roads railroads usually pay 25 per cent and on all heavily traveled roads their portion is 50 per cent.

ARKANSAS

Railroad Commission does not have authority to enforce division of costs. State Highway Commission has power to require railroads to make grade separations and may assume not to exceed 50 per cent of costs on a state road or extension of a state road through a town or city.

CALIFORNIA

Railroad Commission has exclusive authority over all grade crossing eliminations including apportionment of costs. Commission also has power to enforce collection by suit against corporation or governmental body.

Highway Commission may make arrangements with railroads as to division of costs, these divisions being based on previous rulings of railroad commission, the guiding principle being the assumption that costs should be divided in direct proportion to the benefits derived.

In cases of new roads the railroads proportion has been fixed at 25 per cent. In cases of old roads or streets wherein travel has increased until it is a distinct advantage to railway company to eliminate the grade crossing, the railway has contributed 50 per cent.

COLORADO

The Public Utilities Commission has full jurisdiction over grade crossing elimination including power to apportion costs. (See Exhibit "A")

CONNECTICUT

The statute provides that the railroad shall apply to the Public Utilities Commission for elimination of at least one grade crossing each year for every fifty miles of road operated in the state, which crossings to be removed shall be those which, in the opinion of the Directors are among the most dangerous upon the railroad. In case railroad initiates petition it bears the expense.

If the Directors fail to make such applications, the Public Utilities Commission shall, if in its opinion the financial conditions of the railroad warrant, order such crossing or crossings removed, as in the opinion of the Commission the Directors should have applied for the removal of under the provisions of the law. In this case the state pays one-fourth of the expense and the railroad the balance. Such order contingent on appropriation of sufficient funds by the General Assembly. (For many years no crossings have been eliminated under the above provisions).

Municipalities (towns, cities or boroughs) may apply for the elimination of a crossing, in which event the municipality may be assessed not exceeding one-fourth of the whole expense if the highway in question was in existence at the time of construction of

the railroad and not more than one-half of the expense if the highway was constructed since railroad, which it crosses at grade. The remaining cost is assessed against the railroad. Crossings have been eliminated under this provision.

Highway Commission may petition Public Utilities Commission for the elimination of crossings when unable to reach agreement with railroad. State must file plans and estimate of entire cost with Utilities Commission five days previous to hearing. Utilities Commission has power to divide costs.

DELAWARE

There is no Public Service Commission in this state and no public body vested with authority to apportion costs involved in grade separation projects.

There is no law requiring elimination of crossings at joint expense. However, railroads have eliminated several crossings in recent years under agreement with State Highway Commission whereby the costs were equally divided.

State Highway Law prohibits the construction of new highway crossings with railways at grade.

DISTRICT OF COLUMBIA

The Commissioners of the District of Columbia are authorized (subject to appropriations made by Congress) to eliminate grade crossings and apportion one-half of cost to railroads.

The law covering future work provides that no new streets shall be carried across steam railroad tracks at grade, and in case a street is opened across right-of-way the cost of the project on right-of-way shall be equally divided between railroad and municipality, the municipality to pay for portion off right-of-way.

FLORIDA

Railroad Commission has jurisdiction over railroads but is not vested with authority to determine and enforce cost of grade separation projects.

There is no statute in force bearing on or regulating the abolition of grade crossings.

GEORGIA

The Public Service Commission has jurisdiction over railways but is not vested with authority to determine and enforce division of costs in grade separation projects.

The State Highway Commission has authority to determine division of costs subject to judicial review. Code provides that cost be equally divided. The costs of approaches beyond 300 feet from the center line not participated in by the railroad and railroad is not obligated to spend more than $40,000 in any one year. Railroads having gross earnings less than $2,000,000 in preceding calendar year not required to spend more than $30,000.

Commission does not have authority to interfere with or change the grade or alinement of railroad tracks or relocate line of railroad, without its consent.

Code provides that state maintain drainage, surface and pavement of highway and bridge as well as the approaches and guard rails except wood floors on overpasses be maintained by railroad. The railroad maintains foundations, piers, abutments of all underpasses and overpasses within limits of its right-of-way.

IDAHO

Commissioner of public works has authority to negotiate with railroads as to division of costs with right of appeal to Utilities Commission in case of non-agreement.

Costs usually divided on 50-50 basis.

ILLINOIS

Commerce Commission has complete supervision of highway crossings and may apportion costs of elimination. Usual basis is 50 per cent to railroads and 50 per cent to public.

In cases where old crossing has not been closed the apportionment has been less than 50 per cent to the railroad.

The Highway Department recently adopted a policy covering division of costs of separation of State Roads with railroads of which the following are the principal points:

1. Where one or more existing highway grade crossings are closed, the State pays 60 per cent of cost of separation and Railroad 40 per cent.

2. Where no existing grade crossings close state will pay 75 per cent and railroad 25 per cent.

3. Where the railroad is willing to construct a creosoted timber type subway instead of permanent steel and concrete, state will pay 100 per cent of the cost regardless of whether or not existing grade crossings close, on condition railroad maintain structure after built.

4. When Highway Department decides creosoted timber overhead structure is acceptable, state will pay 100 per cent whether or not existing crossings close, on condition that railroad maintain structure after built.

5. Where the highway is located by the state so as to pass near an existing subway or overhead structure which cannot be used in the highway improvement, state will pay 100 per cent of a permanent type of separation either under or over, railroad to maintain the subways and state to maintain the overheads, but if built of creosoted timber in either case maintenance to be taken care of by railroad.

INDIANA

Public Service Commission has jurisdiction over grade separation projects except in cities of more than 20,000 population. Statute provides that cost on state roads be divided 50 per cent to railroad and 50 per cent to state. On other roads division is 75 per cent to railroad and 25 per cent to state. In cities over 20,000 Board of Public Works has jurisdiction and costs are divided 75 per cent to railroad and 25 per cent to public, except cities 45,000 to 90,000 population may agree to pay 35 per cent. Over 100,000 population railroad pays 50 per cent. After separation Highway Department maintains highway and structure supporting it and railroad maintains its roadway and structure supporting same.

IOWA

Railroad Commission has authority to apportion costs. Usual division of costs for both overhead and underpasses has been ⅔ to state and ⅓ to railroad of total cost including approaches. In some cases the state has stood entire expense of overhead structures.

For undercrossings the state maintains highway paving and drainage and railroad maintains structure. For overcrossings state maintains structure and approaches.

KANSAS

State Highway Commission has authority to enforce proper division of costs on state roads. On county roads the railroad and the County Commissioners may agree on division of costs subject to approval of Highway Commission. In case of disagreement Highway Commission may hear the case and divide the costs. On city streets City Commission has power to enforce proper division of cost.

KENTUCKY

State Highway Commission is vested with authority to order elimination of hazardous crossings. Division of costs, including acquisition of land, damages to abutting property, etc., on railroad right-of-way 50 per cent to railroad and 50 per cent to state.

In cities of the first-class Board of Public Works has jurisdiction and code fixes division of costs as 65 per cent to railroad and 35 per cent to city.

Railroad to maintain structure on right-of-way except surface of roadbed of highway.

LOUISIANA

Public Service Commission has jurisdiction over question of division of costs of crossing eliminations.

In one case railroad assumed 50 per cent of cost of structure and state 50 per cent and entire cost of approaches. This case has been used as a basis for other agreements.

MAINE

Public Utilities Commission has authority to order grade separations and to apportion costs upon definite statutory percentages, 10 per cent to towns or cities, 25 per cent to state and 65 per cent to railroads.

Railroads have been able to make agreements with State Highway Commission, etc., under which railroads percentage has been usually 50 per cent or under.

Commission to investigate or otherwise ascertain that the railroad is financially able to finance its portion of work.

MARYLAND

Chapter 327 of the Laws of 1927 of the State of Maryland provides that when state highways and railroads cross at grade and it appears to State Road Commission that such crossing should be eliminated, the Commission may eliminate it or require the railroad company to do so on plans approved by the Commission. One-half of the expense of the work, including damages to adjacent property, to be paid by the railroad and one-half by the State Roads Commission. This applies only to state roads. There is no law covering the elimination of grade crossings other than those on state roads.

In general this state acknowledges the equity of equal participation in the cost of grade crossing elimination projects.

MASSACHUSETTS

Statute provides that elimination projects in municipalities may be done by agreement between railroads and municipalities and costs divided 40 per cent to state and 60 per cent divided between railroad and municipality as agreed.

Department of Public Works required to file annually with Department of Public Utilities, recommendations covering crossings to be abolished and department of Public Utilities to hold hearings and designate program of grade crossing abolition. After hearings, Department of Public Works shall do or have general supervision over the work. Except as otherwise provided railroad shall pay 50 per cent and the other 50 per cent divided between the state and municipality, the latter paying not more than 10 per cent or less than 5 per cent. Street railways affected shall pay actual cost of changing railways and location to conform to order of abolition.

Railroad maintains substructure and superstructure and public maintains pavement and approaches of either over or underpasses.

MICHIGAN

Public Utilities Commission is vested with authority to order grade separations and apportion costs.

Law provides that unless otherwise agreed upon by both public and railroad authorities the cost of constructing and making all separation of grades, the reconstruction of existing grade separations or the alteration of existing grade separations for increased highway or railroad facilities, computed as hereinafter provided shall be borne as follows. Fifty per cent by railroad or railroads interested and 50 per cent by the state, or subdivision thereof, city or village, or the board, commission or other agency interested therein, or jointly by any or all these parties, except where the reconstruction of existing grade separations or the alteration of existing grade separations has not been agreed to by both public and railroad authorities, in which event the commission shall prescribe in its order who shall bear and pay cost of said improvement in whole or in proportion to the interests of the respective parties.

Maintenance of structure and approaches shall be borne by party whose traffic is carried thereon except in complicated cases when commission shall apportion maintenance.

MINNESOTA

The Minnesota Railroad and Warehouse Commission has exclusive authority to separate railroad crossing grades and to apportion costs.

Costs have usually been divided on a 50-50 basis. In some cases the state has paid entire cost of grade separations, but in these they have received some other benefits from railroad company, such as use of its right-of-way, etc.

MISSISSIPPI

State Highway Commission has authority to order grade crossing eliminations subject to appeal to courts. Statute provides that costs be divided equally although some structures have been built on basis of 25 per cent to railroad and 75 per cent to public, 25 per cent being paid by Federal funds.

MISSOURI

Public Service Commission has jurisdiction over all matters relating to hazards and location of present and future grade crossings including apportionment of expense of their elimination.

The apportionment of expense is made on a basis of benefit to interested parties, usually after hearing. Law does not allow State Highway Commission to be assessed more than 50 per cent. In some cases cost of structure only was divided where state received other benefits such as borrow rights on right of way.

MONTANA

Railroad and Warehouse Commission has jurisdiction outside of municipalities and can apportion costs including maintenance. In cities separations are subjects of negotiations between railway and city. Division of costs is usually 56.6 per cent to state and 43.4 per cent to railroad. In some recent cases the state has paid the cost of the approaches.

NEBRASKA

No statutory provision for division of costs of grade separations.

State Railway Commission empowered to designate division of costs outside limits of cities and villages if railroad and county board cannot agree.

General basis of costs 50 per cent to railroad and 50 per cent divided between state and federal aid.

NEVADA

Public Service Commission has full jurisdiction in grade separations including apportionment of costs.

The code provides railroad pay ⅓, state ⅓, and federal aid ⅓.

NEW HAMPSHIRE

Public Service Commission has full jurisdiction including apportionment of costs.

When a railroad applies for authority to place grade crossing and is denied permission the law provides that railroad pay half of cost of substitute structure, the other half of cost to be apportioned by Commission.

No law apportioning costs of a grade separation for an existing grade crossing.

Separation may be ordered by town or city, subject to appeal by railroad to commission, and if so ordered entire cost must be paid by railroad unless agreement made providing otherwise.

Railroads have been able to make agreements with State Highway Commissioners, etc., railroads to pay 50 per cent or under.

NEW JERSEY

Division of cost of grade crossing elimination is fixed by law, 50 per cent by railroads and 50 per cent by state. Total cost to be divided includes moving of municipal water and sewer lines, conduits, subways, etc.

Disputes to be submitted to Board of Public Utility Commissioners whose determination is final, subject to review by courts.

Railroads own and maintain all structures on their right-of-way except approaches and paving.

There is $4,000,000 available for the state's share of work each year.

NEW MEXICO

State Highway Commission may order grade separation. If unable to agree with railroads may apply to District Court, whose orders shall be enforced in same manner as decrees of equity.

Cost of separations to be divided 50-50.

NEW YORK

Transit Commission has jurisdiction over crossings to be eliminated by separation of grades in Greater New York. Public Service Commission has jurisdiction in State out-

side of Greater New York. Commissioners do not have jurisdiction over apportionment of costs.

The law specifies that the railroads pay 50 per cent, State 49 per cent and County 1 per cent.

Either railroad or municipality may borrow funds from state to finance their share of cost and are allotted 50 years to repay debt.

NORTH CAROLINA

Corporation Commission has jurisdiction to require grade separations and to apportion costs.

Several agreements provide equal division of costs.

Jurisdiction given Corporation Commission does not deprive cities of authority over their streets for protection of their citizens.

NORTH DAKOTA

Railroad Commission has jurisdiction but Railway Company may negotiate with Highway Department, county or city, as case may be. General division of costs has been 50 per cent railway and 50 per cent to public. In some cases where other factors were involved such as use of railway's right-of-way, or new bridge replacing old structure paid for by railway, state has assumed more than 50 per cent of project.

OHIO

Jurisdiction is lodged with Courts of Common Pleas having jurisdiction over territory in which projects are presented.

On state highway cost is on a 50-50 basis.

On city streets and county highways, not a part of state highway system, cost is borne 65 per cent by railroad and 35 per cent by municipality or county.

OKLAHOMA

Corporation Commission has full jurisdiction including division of costs and assignment of maintenance. City, town or municipality shall not be assessed more than 50 per cent of cost.

OREGON

Public Service Commission has full power regarding new grade crossings and the separation of grades, including power to apportion costs.

Jurisdiction of Commission does not extend to cities over 100,000 population.

In some cases by agreement with counties expense has been equally divided.

In other cases where State Highway Commission was involved the railroad paid 40 per cent, the state and county 60 per cent where new structure resulted in elimination of grade crossing.

PENNSYLVANIA

Public Service Commission has exclusive power regarding grade separations and apportionment of expense.

Cost is divided on basis of conditions presented at hearing.

In general cost is divided 50 per cent to railroad and 25 per cent each to county and state.

RHODE ISLAND

Town Council may request railroad in writing to eliminate grade crossing. If railroad neglects to do so council may appeal to Public Utilities Commission which has power to decide on elimination, subject however, to appeal to Supreme Court within 30 days.

Supreme Court has full power including division of costs.

If railroad neglects or refuses to change grade after ruling by court, town council may make change and in action against corporation recover all charges and expenses.

Grade crossing elimination has not been extensive and cost has usually been divided by agreement.

SOUTH CAROLINA

Railroad Commission has full authority over separation of grades.

The law provides that for overcrossings railroad shall pay 50 per cent of cost including approaches not exceeding 150 feet either side, the state to pay remaining 50 per cent. For an undercrossing the state shall pay 50 per cent of cost to cut through railroad fill and of bridge; cost of approaches and drainage paid by state.

Authority of Railroad Commission does not extend to crossings located in municipalities, which are under control of local municipal government.

SOUTH DAKOTA

Highway Commission and Board of County Commissioners have authority, subject to approval of Board of Railroad Commissioners, to eliminate dangerous grade crossings where practical, expense to be divided equitably.

If lands appropriated for relocation of crossing, total cost of project to be divided 50-50.

In case of separation of grades railroad to pay for improvements on right-of-way and provide drainage, state or county to pay remainder, additional right-of-way to be provided by state and county.

If agreement cannot be reached between Highway Commission and railroad on distribution of cost of work, Highway Commission may appeal to Railroad Commission, which has power to apportion cost.

Railroad to maintain structures.

TENNESSEE

State Highway Commission has power to eliminate grade crossings. Railroads have the right of appeal to the Railroad and Public Utility Commission for change in plans or extension of time.

Law provides that total cost of grade separations be divided on a 50-50 basis.

Railroad to maintain all that part of any overpass or underpass and approaches on its right-of-way, also that part of any overpass structure or approach not supported by a fill whether on right-of-way or not, except surface of highway.

TEXAS

No state commission or other body with authority to apportion expense.

Custom is to handle each case as an individual and make best agreement possible.

UTAH

Public Utilities Commission has full authority including apportionment of costs.

No definite policy of apportioning costs. Cost generally divided on 50-50 basis.

VERMONT

Railroads are required by Public Service Commission to spend not less than $75 per year per mile of operated line in state for elimination of grade crossings. Commission has relieved railroads of this requirement except in special cases.

When existing crossing eliminated railroad pays 65 per cent, state 25 per cent, municipality 10 per cent.

Where new highway established railroad pays 60 per cent, state 25 per cent, municipality 15 per cent.

In some cases railroads have made agreements with Highway Commission for a 50-50 division of costs.

VIRGINIA

State Corporation Commission has full authority including apportionment of costs.

Code provides that cost of a grade separation to be on a 50-50 basis, railroad to maintain crossing, except in cases where improvement is made in any railroad it shall be made at railroad's expense.

When Highway Commission purposes to change alignment of highway eliminating one or more crossings, railroad shall be notified and shall be liable for one-half the excess cost of constructing road along a line eliminating such, over the estimated cost

of similarly improving road along the line including the grade crossing. New alignmer shall not exceed five miles in length. One-half of excess cost chargeable to railroad sha not exceed their legal proportion of cost of overhead or underground crossing at poir where grade crossing is eliminated. Railroad may appeal to State Corporation Con mission if dissatisfied with excess cost, the commission to determine amount.

WASHINGTON

Department of Public Works has jurisdiction including apportionment of cost: except in cities of first-class. Cases are considered on their merits and division of cos to the Railway Company has varied, and lately has not exceeded 50 per cent. Recen cases indicate fair attitude toward railways.

In municipalities practice varies from an equal division of cost to 100 per cent t the railways.

WEST VIRGINIA

Statutes provide that State Road Commission, County Courts, or Municipal Council have jurisdiction and power to order a railroad to separate crossing grades.

Cost to be divided equally between railroad and State Road Commission, Count: or Municipality as the case may be.

WISCONSIN

Railroad Commission has authority on petition to order elimination of grade cross ings and fix proportion of costs. Cost is not divided on a fixed basis, each case bein treated on its merits.

WYOMING

Public Service Commission has authority in grade eliminations including apportion ment of costs. There have been few separations in this state but all have been appor tioned on a 50-50 basis.

Exhibit A

STATES WHEREIN RAILROADS HAVE WORKING AGREEMENTS NOT AUTHORIZED BY LEGISLATURES

Colorado

State Highway Department and railroads formed following working agreement to b used as a basis for future grade separation work.

(1) The division of costs to be one-third paid by the railroad company and two thirds by the Highway Department.

(2) The Highway Department to design the crossing with as favorable an angl of intersection as practicable, consistent with best practice as to the highway require ments, but whatever the angle, it is to have no bearing in the division of costs.

(3) The cost of the crossing separation is to be computed from the normal highwa grade on one side of the railway track to the normal grade on the other side, and i irrespective of the railway right-of-way lines.

(4) The cost of surfacing the roadway, either by cement or bituminous paving o by crushed stone or gravel, is not to be computed in the cost of grade separation. Th entire cost of putting the roadbed in shape to receive the paving or surfacing is to b computed as a part of the cost of the grade separation.

(5) It is understood that in all cases the crossing layout and design of structur will be submitted by this Department to the Railroad Company, and full consideratior given to their comments and suggestions. Attention is called to the fact that heretofor in all cases of separation by underpass, the Railroad Company has itself designed th structure, and it is the intention of this Department to continue the policy. As hereto fore the Department will design the viaducts but will submit these designs to the Rail road Company for approval.

(6) It is understood that while the above sets out the general principles on which the problem of grade separation and the division of costs is to be considered, there may be and are many minor related items that are left for agreement at the time of discus sion of the particular crossing.

Florida

Agreement between Florida State Road Department and Railroads dated July 3, 1924, has been used as basis for crossing eliminations.

(1) Whenever a state road crosses an existing railroad the State Road Department may determine whether the crossing be at grade, or by overpass or underpass. This also included existing state roads.

(2) OVERPASS: The railroad involved shall be responsible for one-half of the entire cost of the bridge from abutment to abutment including same. The State Road Department shall be responsible for the remaining cost. The railroad will maintain the supporting abutments and bents and the State Road Department the remainder. An overpass shall be constructed for at least two tracks unless waived by the railroad.

(3) UNDERPASS: The railroad shall be responsible for one-half the expense of all excavations "through the existing railroad fill of the railroad right-of-way and one-half the complete cost of the structure necessary to carry the railroad tracks on the railroad right-of-way including the foundation, substructure, and superstructure; and the State Road Department shall be responsible for the remainder of the cost." The railroad shall maintain the substructure and superstructure and the State Road Department the roadway and drainage. Such structure shall be built to accommodate at least two tracks unless waived by the railroad.

(4) GRADE CROSSING: The railroad company is responsible for one-half the cost between points ten ft. (10′) beyond the ties on each side of the tracks. The State Road Department is responsible for the remaining cost. Maintenance between aforesaid is by the railroad.

(5) A new railroad line crossing an existing state road: The railroad elects whether the highway shall be carried over or under the railroad unless agreement is made with the State Road Department to cross at grade.

(a) OVERPASS: The State Road Department shall bear one-half the expense of the bridge spanning the track. The railroad bears the entire expense of the approach fills, which shall be on a 5 per cent grade unless otherwise agreed upon, and shall cooperate with the State Road Department in reconstructing the pavement to an amount equal to the appraised value of the existing pavement which has been disturbed.

(b) UNDERPASS: The State Road Department pays one-half the cost of the railroad bridge spanning the highway and the railroad provides the fills.

Construction of additional tracks on existing right-of-way of an existing railroad is not considered new construction, and Sections (1), (2), (3) and (4) shall govern.

(6) No railroad is required to spend in one calendar year more than ⅕ of 1 per cent of total gross earnings derived from both interstate and intrastate business in Florida during the calendar year next preceding, unless agreed to by the railroad.

(7) This agreement is effective July 3, 1924.

(8) Whenever an underpass or overpass is substituted for a grade crossing such grade crossing shall be closed.

Wisconsin

State Highway Commission has working agreement with large railroads to divide expense of elimination on state trunk highway 40 per cent to railroad and 60 per cent to state.

General Data

In a number of other states railroads have working agreements with State Highway Commissions, etc., for which there is no legal authority.

These agreements, however, have been accepted as a basis for negotiations and recognized practice, and as a result of this some may eventually be adopted by legislatures.

Recommendation

It is the recommendation of your Committee that the report be received by the Association as information.

CONDENSED STATEMENT OF LAWS AND PRACTICES COVERING GRADE SEPARATIONS

State	Kind of Road	Percentage Division of Cost		Who has jurisdiction over eliminating grade crossings					Remarks
		R. R.	Other	State Highway Com.	Public Service Com.	City Auth.	County Auth.	Courts	
Alabama	State	50	50	x					State has jurisdiction on county roads where state funds used. Cities over 35000 can compel R. R. 's to pay 100%.
	County	50	50	x			x		
	City	100				x			
Arizona	State	25–50	75–50		x				In several recent cases cost to R. R. has been 25 to 50% averaging about 40%. Old heavy traveled roads 50–50.
	County	25–50	75–50		x				
	City	25–50	75–50		x				
Arkansas	State	50	50	x					State Highway Commission may not assume to exceed 50% of costs on state road or extension through town or city.
	County	50	50	x					
	City	50	50	x					
California	State	25–50	75–50		x				New roads railroad pays 25%. Old established roads railroad pays 50%.
	County	25–50	75–50		x				
	City	25–50	75–50		x				
Colorado	State				x				Agreement with State Highway Commission provides for division ⅓ Railroad; ⅔ State.
	County				x				
	City				x				
Connecticut	State	75	25		x				In municipalities if old established crossing city pays 25%. If recent not more than 50%.
	County	75	25		x				
	City	75–50	25–50		x				
Delaware	State	50	50	x					No public body vested with authority in grade separation. Separations made by agreements between Highway Dept. & Ry.
	County	50	50	x					
	City	50	50						

Dist. of Columbia									Grade separations made and financed by act of Congress. 50-50 basis.
Florida	State								No statute regulating or abolishing grade crossings. Agreement 1924 between State Road Dept. & R. R.'s divides cost 50-50.
	County								
	City								
Georgia	State	50	50	x	x			x	P. S. C. has jurisdiction excepting costs. Highway Com. tries costs subject to judicial review. State maintains overpasses. R. R. underpasses.
	County	50	50	x	x			x	
	City	50	50	x	x			x	
Idaho	State	50	50		x				Cost to be determined by agreement or ruling by Public Service Commission.
	County	50	50		x				
	City	50	50		x				
Illinois	State	50	50		x				Commerce Commission has full jurisdiction. Where old crossings not eliminated R. R.'s pay less than 50%.
	County	50	50		x				
	City	50	50		x				
Indiana	State	50	50		x				Highway Dept. maintains overpasses. Railroad maintains underpasses.
	County	75	25		x				
	City	75–50	25–50			x			
Iowa	State	33⅓	66⅔		x				State maintains overpasses. Railway maintains underpasses except approaches. R. R. Com. has jurisdiction.
	County	33⅓	66⅔		x				
	City	33⅓	66⅔		x				
Kansas	State			x					Costs fixed by agreement or decision by State Highway Commission.
	County			x			x		
	City					x			
Kentucky	State	50	50	x					Assessment of railroad portion is for amount on right of way.
	County	50	50	x					
	City	65	35			x			

CONDENSED STATEMENT OF LAWS AND PRACTICES COVERING GRADE SEPARATIONS—Continued

State	Kind of Road	Percentage Division of Cost		Who has jurisdiction over eliminating grade crossings					Remarks
		R. R.	Other	State Highway Com.	Public Service Com.	City Auth.	County Auth.	Courts	
Louisiana	State	50	50		x				Assessments based on past practice.
	County	50	50		x				
	City	50	50						
Maine	State	65–50	35–50	x	x				Statutes provide 65-35 division of costs. Various agreements with St. Highway Dept. on 50–50 basis.
	County	65–50	35–50	x	x				
	City	65–50	35–50	x	x				
Maryland	State	50	50	x					Statutes provide 50-50 basis on state roads. No law for other roads but state acknowledges equity 50-50 basis.
	County	50	50						
	City	50	50						
Massachusetts	State	50	50		x				Dept. of Public Works handles subject approval of Pub. Utilities Com. R. R. maintains structure, public maintains paving and approaches.
	County	50	50		x				
	City	50	50		x				
Michigan	State	50	50		x				State maintains overpasses. R. R. maintains underpasses.
	County	50	50		x				
	City	50	50		x				
Minnesota	State	50	50						R. R. and Warehouse Commission has exclusive authority. State has paid entire cost when rec'd other compensation.
	County	50	50						
	City	50	50						
Mississippi	State	25–50	75–50	x				x	Highway Commission has authority subject to appeal to courts.
	County	25–50	75–50	x				x	
	City	25–50	75–50	x				x	

Missouri	State	50	50		x				In some cases cost of structure only is divided where state receives other benefits.
	County	50	50		x				
	City	50	50		x				
Montana	State	43.4	56.6		x				Railroad and Warehouse Commission has jurisdiction outside of municipalities.
	County	43.4	56.6		x				
	City	43.4	56.6		x				
Nebraska	State	50	50		x		x		Railway Commission to designate division of costs where agreement can not be reached.
	County	50	50		x		x		
	City	50	50		x	x			
Nevada	State	33 1/3	66 2/3		x				Railroad 1/3, State 1/3, Federal Aid 1/3.
	County	33 1/3	66 2/3		x				
	City	33 1/3	66 2/3		x				
New Hampshire	State	50	50		x				When separation ordered by City or Town R. R. must pay 100% unless agreement made
	County	50	50		x				
	City	50	50		x				
New Jersey	State	50	50		x			x	Railroads own and maintain all structures on right of way except approaches and paving.
	County	50	50		x			x	
	City	50	50		x			x	
New Mexico	State	50	50	x				x	District Court to rule in case of disagreement.
	County	50	50	x				x	
	City	50	50	x				x	
New York	State	50	50		x				Transit Commission has jurisdiction in greater New York. Public Service Commission outside of greater New York.
	County	50*	50		x				
	City	50	50						
North Carolina	State	50	50		x				Several agreements provide 50-50 basis of costs. Corporation Commission has jurisdiction.
	County	50	50		x				
	City	50	50			x			

CONDENSED STATEMENT OF LAWS AND PRACTICES COVERING GRADE SEPARATIONS—Continued

State	Kind of Road	Percentage Division of Cost		Who has jurisdiction over eliminating grade crossings					Remarks
		R. R. *	Other	State Highway Com.	Public Service Com.	City Auth.	County Auth.	Courts	
North Dakota	State	50	50		x				In some cases State has assumed more than 50 per cent where other factors involved.
	County	50	50		x				
	City	50	50		x				
Ohio	State	50	50					x	Courts of common pleas have jurisdiction.
	County	65	35					x	
	City	65	35					x	
Oklahoma	State	50	50		x				Corporation Commission has full jurisdiction.
	County	50	50		x				
	City	50	50		x				
Oregon	State	50–40	50–60		x				Commission does not have jurisdiction in cities over 100,000.
	County	50–40	50–60		x				
	City	50–40	50–60			x			
Pennsylvania	State	50	50		x				Costs divided on basis of conditions presented at hearing, usually on 50-50 basis.
	County	50	50		x				
	City	50	50		x				
Rhode Island	State	By Agreement			x			x	Supreme Court rules in cases of disagreement. Crossing elimination not extensive.
	County	By Agreement			x			x	
	City	By Agreement			x	x		x	
South Carolina	State	50	50		x				Approaches and drainage for undercrossing paid for by state. Approaches for overcrossing beyond 150 feet paid by State.
	County	50	50		x				
	City	50	50			x			

South Dakota	State	50	50	x	x		x		Railway Commission has jurisdiction in case of no agreement. Railroad maintains structures.
	County	50	50	x	x		x		
	City	50	50	x	x		x		
Tennessee	State	50	50	x	x				Railroad maintains all structures also approaches on right of way except surface of highway.
	County	50	50	x	x				
	City	50	50	x	x				
Texas	State	By Agreement							No jurisdiction. Custom to handle each case as an individual.
	County	By Agreement							
	City	By Agreement							
Utah	State	50	50		x				No definite policy of apportioning costs. Precedent 50-50 basis.
	County	50	50		x				
	City	50	50		x				
Vermont	State	65–50	35–50		x				Existing crossings 65-35; new crossings 60-40; Some agreements with S. H. Dept. 50-50.
	County	65–50	35–50		x				
	City	65–50	35–50		x				
Virginia	State	50	50	x					Corporation Commission has jurisdiction over Highway Commission. State may change road on same cost basis.
	County	50	50	x					
	City	50	50	x					
Washington	State	25–50	50–75						Department of Public Works has jurisdiction except in cities over 20,000.
	County	50	50						
	City	50–100	50			x			
West Virginia	State	50	50	x					Statutes provide jurisdiction for State Road Commission, County Court or Municipal Councils.
	County	50	50				x		
	City	50	50			x			

CONDENSED STATEMENT OF LAWS AND PRACTICES COVERING GRADE SEPARATIONS—Continued

State	Kind of Road	Percentage Division of Cost		Who has jurisdiction over eliminating grade crossings					Remarks
		R. R.	Other	State Highway Com.	Public Service Com.	City Auth.	County Auth.	Courts	
Wisconsin	State	40	60		x				R. R. Commission has jurisdiction. Highway Commission has working agreement with R. R.'s 40-60.
	County	40	60		x				
	City	40	60		x				
Wyoming	State	50	50		x				Few separations but all on 50-50 basis.
	County	50	50		x				
	City	50	50		x				

Appendix E

(5) DRAINAGE METHODS FOR GRADE CROSSING ELIMINATION PROJECTS AND DIVISION OF COST CHARGEABLE THERETO

A. R. Dewees, Chairman, Sub-Committee; E. L. Anderson, F. J. Blickensderfer, John Carmichael, L. B. Curtiss, A. T. Danver, W. M. Jaekle, L. J. Riegler, C. E. Robinson, H. M. Shepard, A. H. Utter, R. F. Wood, A. M. Zabriskie.

It is the sense of this Committee that drainage methods for grade crossing elimination projects are engineering details to be considered in connection with each individual project.

Likewise, the division of costs chargeable thereto is a problem that must be determined as part of the division of cost of the entire project.

Recommendation

It is the recommendation of your Committee that the report be received by the Association as information.

Appendix F

(6) USE OF CONCAVE STREET SECTIONS FOR GRADE SEPARATION SUBWAYS AND TRANSITION FROM CROWN TO CONCAVE SECTIONS

E. R. Lewis, Chairman, Sub-Committee; E. L. Anderson, John Carmichael, C. W. Charleson, S. N. Crowe, C. A. Dayton, R. C. Gowdy, A. G. Holt, A. E. Korsell, L. J. Riegler, W. S. Lacher, H. M. Shepard, R. F. Wood.

Definition

CONCAVE STREET SECTION.—A hollow roadway cross-section of curved or angular alinement, lowest in the middle, whence it rises gradually to high points at the curbs.

Vertical Clearance

The change in vertical clearance made possible by the use of concave as compared with convex cross-sections equals the sum of the rise and fall from the horizontal in the convex and concave designs. Underclearances of subway bridges may be increased at the center and well toward the curbs, thus providing extra height for cover plates of girder bridges and for overhead trolley car systems. The primary urge for vertical clearance far in excess of the ordinary automotive vehicle and load has been predicated largely on the accommodation of electric street cars with overhead trolleys, existing or prospective. In some cases convex pavements have been removed and replaced in subways by concave pavements, especially to permit the routing of such street car lines through the subway. Such alterations are made without disturbance of any structural element except the pavement and its drainage facilities.

Since streetcar tracks occupy the central part of the roadway and require greater vertical clearance than other street traffic, the concave section clearly conforms to actual traffic requirements, whereas the convex section places the streetcar lines in the zone of least clearance. Street traffic studies indicate that automotive drivers increase speed through subways and drive well away from the curbs, leaving three to five feet of pavement adjacent to curb lines practically unused. It is feasible in designing concave section pavements to depress from curb lines to five foot points sharply as compared with the

remaining central portion, thus widening the zone of low pavement to the limits of actual travel, the result being an approach to elliptical rather than the circular form of curve.

While the difference between the convexity and concavity of cross-sections is at most a matter of inches, this difference assumes economic importance because it influences the major elements of cost. Drainage structures, notably the lengths and numbers of sewer connections and the number of catch basins, are minimized, while the separation of the grades and general extent of the work is favorably affected.

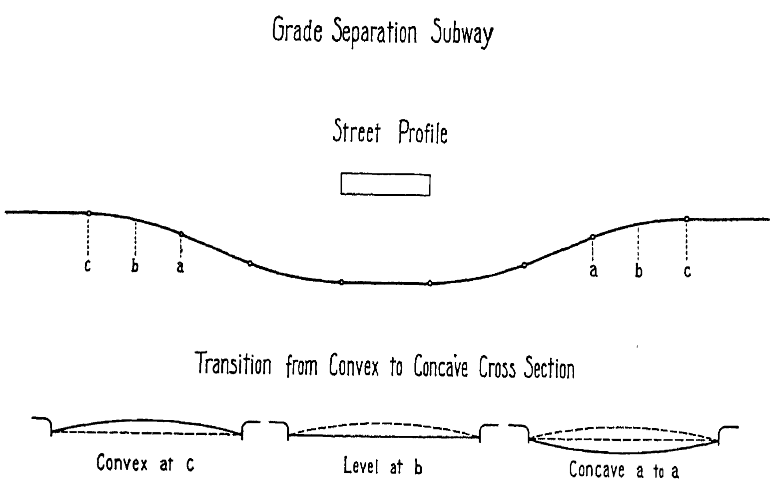
Transitions

Transitions from concave to convex section at tops of subway approaches are made by warping from concave to flat to convex surface within the limits of the vertical curve provided to connect the street grade with the subway approach grade. The concave section is of distinctive advantage at cross street intersections which are located within subway approach limits, because the concavity forms a desirable valley with which the descending grades of the cross streets may be connected without reverse vertical curves, this arrangement tending to simplify the drainage as well as the pavement warping.

Recommendation

It is the recommendation of your Committee that the report be received by the Association as information.

The concave street section is recommended for consideration of designers of grade separation subways.



Appendix G

(7) STUDY AND RECOMMEND STANDARD SPECIFICATIONS FOR STREET CROSSINGS, OVER RAILWAY TRACKS, BOTH STEAM AND ELECTRIC

V. R. Walling, Chairman, Sub-Committee; F. D. Batchellor, L. B. Curtiss, A. T. Danver, G. N. Edmondson, C. F. Edwards, H. W. Fenno, P. M. Gault, R. C. Gowdy, J. P. Hallihan, H. A. Hampton, M. V. Holmes, W. M. Jaekle, W. B. Knight, H. M. Shepard, W. L. Young.

Serious consideration has been given to the investigation and study of this assignment, during the year. A tentative report was submitted at the last meeting of Committee IX, but it was decided to return the subject to the Sub-Committee for further investigation and preparation of additional information. Progress is reported in connection with this assignment.

Recommendation

It is the recommendation of your Committee that the subject be continued for further study and report.

Appendix H

(8) USE OF HIGHWAY CROSSING PLANK AND SUBSTITUTES THEREFOR

F. D. Batchellor, Chairman, Sub-Committee; C. W. Charleson, S. N. Crowe, C. A. Dayton, L. C. Frohman, A. G. Holt, W. B. Knight, A. E. Korsell, W. C. Swartout, A. H. Utter, R. F. Wood, W. L. Young.

This assignment has been studied under various headings since 1922 and finally resulting in 1925 in the adoption of "Specifications for Bituminous Crossings", which was approved for publication in the Manual. Since that time there has been an increase in the use of bituminous and other kinds of material and a corresponding decrease in the use of crossing plank.

The subject assigned has received serious study and consideration during the past year and a tentative report was prepared, which was submitted at the last meeting of Committee IX, with the result that the assignment was referred back to the Sub-Committee for further study.

Recommendation

It is the recommendation of your Committee that the subject be continued for further study and report.

Further Recommendation

It is the further recommendation of your Committee that further study of this subject be conducted under the caption of—"Study the types and relative economy of different types of highway crossings, collaborating with Committees I—Roadway and V—Track".

Appendix I

(9) STOCK GUARDS—TYPES, USES AND NECESSITY

Maro Johnson, Chairman, Sub-Committee; E. L. Anderson, F. D. Batchellor, F. J. Blickensderfer, John Carmichael, C. W. Charleson, A. R. Dewees, H. W. Fenno, H. A. Hampton, A. G. Holt, W. B. Knight, W. S. Lacher, L. J. Riegler, C. E. Robinson.

This report is based on information furnished by thirty-two railroads representing all sections of the United States, except the extreme northwest, and Canada. The nature of the information received makes it seem logical to reverse the order of treatment suggested by the title.

The conditions which brought about the almost universal requirement for the installation of stock guards in the early State laws affecting railroads no longer exist in a large portion of the United States. Farmers are prohibited by law from allowing stock to run at large and as a result farm fences are more effective. Better materials are available for making them effective. Because of motor traffic less stock is driven on the highway, much of it being hauled in trucks to rail sidings or direct to market. In some parts of the country less stock than formerly is raised. As a consequence the use of stock guards is being quite generally discontinued throughout the northern and eastern sections, usually by not making replacements. Farmers, as well as State and local authorities, have recognized the changed condition and little or no effort is made to enforce the legal requirements.

In the southwest, and to some extent in the south, their use is continued, there being less fencing in these sections, and it seems to be generally felt that stock claims are thereby reduced and also that the possibility of accident is lessened. However, there is some difference of opinion as one correspondent who has discontinued the use of stock guards advises that the presence or lack of them made little difference in fixing liability for stock killed, and another that in several States it has been considered less expensive to pay the few claims presented than to maintain and renew the guards. On some of the southwestern lines use is confined to public crossings in localities where conditions require them and to the end of fenced sections of right-of-way, though some guards are maintained at private crossings at the request of landowners, and opposite fences dividing land of different owners.

In Canada stock guards are required by law, the public is more insistent on its being enforced and their use is quite universal though the Railroad Commission has authority to relieve a railroad from compliance in specific cases on application.

Most railroad engineers are familiar with the various types of stock guards and there appears to be little need for extensive detail descriptions. In general they are constructed of wood or steel or a combination of these materials and attached to the top surface of the ties, though in the southwest a few of the old pit guards remain.

Wooden guards consist of hardwood slats of triangular section with one apex of the triangle at the top; or rectangular sections chamfered to an edge or set at an angle; the slats being separated by spacers or spools and bolted together to form sections; or of tapered wooden rollers fastened in a metal frame. The sections of either type are spiked to the top surface of the tie.

There is greater variety in metal guards, some of which are placed upon the surface of the ties and others partly or wholly between the ties. Of the former the following kinds have been reported in use:

(a) Flat steel plates about No. 8 gage punched to form fins or prongs which project above the surface,

(b) Strips of sheet steel either flat or buckled and similarly deformed,
(c) Slats of flat steel bolted together similar to wooden slat guards and smooth or toothed on top edge,
(d) Scrap structural angles welded to pairs of flat bars to form sections,
(e) Discarded boiler flues.

In the second group are—

(f) Sections of "L" shaped sheet steel laid over the top of the ties and presenting a sloping surface to the animal.
(g) Sloping steel plates toothed at the top and held in a frame placed between ties with a triangular wooden strip nailed along the top of the tie.

All of these types are said to be reasonably effective in preventing the passage of large animals, but some of them are less so with small stock, and there is likewise difference in the cost of maintenance.

The Committee makes no recommendations with reference to use of the various types, there being now in the Manual a set of principles which quite fully cover the conditions which stock guards should be designed to meet.

Recommendation

It is the recommendation of your Committee that the report be received by the Association as information.

Exhibit B

A.R.A. SIGNAL SECTION SPECIFICATION 15633.

REFLECTOR UNITS

1. Purpose

(a) The purpose of this specification is to provide a reflector unit for reflector signs for railroad highway grade crossing protection.

2. Tender

(a) The tender shall be for apparatus meeting the requirements of this specification. If the Contractor wishes to vary from the specification, a tender may be submitted covering the apparatus he desires to furnish. This tender shall be accompanied by full information showing wherein the requirements of this specification are not met.

3. Alternate Requisites

(a) Alternate requisites section 15633 forms a part hereof.

4. Material and Workmanship

(a) Material and workmanship shall be first-class in every respect.

5. Type

(a) The reflector units shall be in accordance with Purchaser's requirements. *R-5-a.

6. Lens

(a) The lens shall be made of clear, practically colorless glass of uniform reflecting power. It shall be accurately formed and free from all defects which would affect its optical or physical properties. It shall be practically free from chromatic aberration when viewed within an angle of 30 deg. from its axis.

(b) The lens shall be so designed that a light at any point within 30 deg. of the axis of the lens will be reflected to a point 40 in. above the source with satisfactory intensity. The source of light shall be an approved type of automobile headlight and shall be located 300 ft. from reflector unit.

7. Reflector Unit

(a) The reflector unit shall be of substantial design, accurately formed and constructed for correct focus. *R-7-a.

8. Mounting

(a) The reflector unit shall be designed so as to enter the aperture in the face of sign from the rear and shall be held in a fixed relation to the face of sign with its axis normal to the aperture.

(b) The reflector unit shall be so constructed that no metal of the reflector unit retainer or housing shall be exposed to view when the reflector unit is assembled in the sign. *R-8-b.

9. Inspection

(a) Purchaser may inspect material at all stages of manufacture.

(b) Purchaser may inspect the completed product to determine that the requirements of this specification have been met.

(c) If material has not been accepted at point of production and if, upon arrival at destination, it does not meet the requirements of this specification, it may be rejected, and the Contractor, upon request, shall advise the Purchaser what disposition is to be made of the defective material. Contractor shall pay all freight charges.

(d) If Purchaser is to make inspection at point of production it shall be so stated.

10. Tests

(a) Tests may be made at point of production, or on samples submitted, and may also be made at destination.

* Section 15633. Alternate requisites.

(b) Contractor shall give the Purchaser sufficient notice of time when material will be ready for testing.

(c) Contractor shall provide, at point of production, apparatus and labor for making required tests under supervision of the Purchaser.

(d) If tests are to be made at point of production, the Purchaser shall so state and also indicate which of the tests herein specified are to be made and what portion of the material shall be tested.

(e) The following tests shall be made:

1. Ability to resist corrosion.
2. Integrity of sealing.
   (a) Immersion test.
   (b) Hydraulic pressure.

(f) Sampling.

1. One hundred reflector units will be selected by the Purchaser at random from a lot of at least 2500.
2. From the group of 100 units, 25 will be selected at random for tests.

11. Description of Tests

(a) Salt-water spray (corrosion test).

1. The complete reflector units as used in the sign shall be sprayed with a 20 per cent salt-water solution for 48 hours. Reflector units shall then be examined for evidence of corrosion; if any appear the lot represented by the samples shall be rejected.

(b) Additional tests shall be in accordance with Purchaser's requirements. *R-11-b.

12. Packing

(a) Material shall be so prepared as to permit convenient handling and to protect against loss or damage during shipment.

13. Marking

(a) Purchaser's order, requisition and package number, name of Consignor, and name and address of Consignee, shall be plainly marked on outside of package.

14. Warranty

(a) Contractor shall warrant the material covered by this specification to be free from defects in material and workmanship under ordinary use and service, his obligation under this warranty being limited to making, at point of production, any part or parts to replace those which shall be found defective within two years after shipment to the Purchaser. This warranty shall not apply to any apparatus which shall have been repaired or altered in any way by anyone other than the Manufacturer thereof, so as to affect, in the Contractor's judgment, its proper functioning or reliability, or which has been subject to misuse, negligence or accident.

15633. Alternate Requisites

R-5-a

The reflector unit shall be of the $\left\{\begin{matrix}\text{double}\\\text{single}\end{matrix}\right\}$ refraction type.

R-7-a

1. When the reflector unit is of the double refraction type it shall be accurately fitted to the lens and the two shall be sealed into a corrosion resisting retainer so as to form a joint that will prevent the admission of liquid or gas between the reflector and lens.

2. When the reflector unit is of the single refraction type the reflector backing shall consist of a heavy coat of metallic silver. It shall be homogeneous, evenly applied to the surface of the glass and be so fitted as to form an air-tight joint between it and the glass. The backing shall be such that it will prevent the admission of air or any foreign substance between it and the glass. Over the reflective backing shall be placed

* Section 15633. Alternate requisites.

a protective backing of one heavy coat of metallic copper, and over this copper plate a coating of protective material which shall so seal the backing as to render it waterproof and air-tight.

R-8-b

When specified by the Purchaser, the reflector unit may be so constructed that not more than $\frac{1}{32}$ in. of the retainer or housing shall be exposed to view when the reflector unit is assembled in the sign.

R-11-b

1. When the reflector unit is of the double refraction type:
   (a) The reflector unit shall be alternately immersed for ten minutes in two baths of colored water, one at a temperature approximately 33 deg. F., the other 170 deg. F. Repeat this alternate immersion ten times, after which the reflector units shall be examined for leakage. If leakage has occurred the lot represented by the samples shall be rejected.
   (b) The sealing between the lens and the cap of the reflector unit shall be such as to be water-tight under a hydraulic pressure of 10 lb. per square inch in colored water for a period of 1 minute. After the reflector units have been subjected to this test they shall be examined for leakage. If leakage has occurred the lot represented by the samples shall be rejected.
2. When the reflector unit is of the single refraction type:
   (a) The backing shall not be affected by either 20 per cent salt-water solution at room temperature, fresh water at 170 deg. F. or a dry temperature of 170 deg. F. The backing shall be subjected to the salt water for a period of 24 hours and to the fresh water for a period of 4 hours immediately following the salt-water immersion and then kept at a dry temperature of 170 deg. F. for 4 hours. The protective coating shall be of such material and so applied as not to be readily rubbed off after the above tests have been made consecutively. If glass has cracked during the test or if reflective backing has been damaged, or if protective coating is readily rubbed off, the lot represented by the samples shall be rejected.

DEFINITIONS

Aberration, Chromatic.—A condition encountered when parallel rays of light impinged upon a prism or lens are grouped into different distinct colors due to the varying degree of refraction as between them.

Reflector Unit.—A device designed to reflect, in the direction of the light source, a substantial amount of the light impinged upon it.

Reflector Unit, Double Refraction.—A type of reflector unit in which the light to be reflected passes through and beyond the refracting medium thereby changing its direction when entering and again when leaving.

Reflector Unit, Single Refraction.—A type of reflector unit in which the light to be reflected passes through but not beyond the refracting medium thereby changing its direction only when entering.

A.R.A. SIGNAL SECTION SPECIFICATION 15533.

RAILROAD HIGHWAY GRADE CROSSING SIGNS

1. Purpose

(a) The purpose of this specification is to provide signs of various designs for railroad highway grade crossing protection.

2. Drawings

(a) Purchaser's drawings referred to in this specification form an essential part hereof.

(b) Contractor shall furnish with his tender, drawings forming an essential part thereof.

(c) Drawings forming an essential part hereof are as follows:

1. 90 Deg. Cast Iron Crossing Sign—Drawing 1640.
2. Adapter Clamp for Crossing Sign—Drawing 1641.
3. 90 Deg. Reflector Crossing Sign Assemblies—Drawing 1642.
4. 90 Deg. Reflector Crossing Sign Details—Drawing 1643.
5. Cast Iron Track Sign—Drawing 1644.
6. Reflector Track Sign—Drawing 1645.
7. Reflector Stop on Red Signal Sign—Drawing 1646.
8. Adapter Clamp and Details for Signs—Drawing 1647.
9. Reflector Stop When Swinging Sign—Drawing 1648.
10. Reflector Crossing Signal Marker—Drawing 1649.
11. Details of Numerals for Track Signs—Drawing 1650.
12. ....
13. ....

3. Tender

(a) The tender shall be for apparatus meeting the requirements of this specification. If the Contractor wishes to vary from the specification, a tender may be submitted covering the apparatus he desires to furnish. This tender shall be accompanied by full information showing wherein the requirements of the specification are not met.

4. Alternate Requisites

(a) Alternate requisites section 15533 forms a part hereof.

5. Material and Workmanship

(a) Material and workmanship shall be first-class in every respect.

6. Gray Iron Castings

(a) Gray iron casting shall be in accordance with specification 1630.

7. Sheet Steel

(a) Sheet steel shall be corrosion resisting. The total amount of carbon, manganese, phosphorus, sulphur and silicon shall not exceed 0.70 per cent. If the total amount of these five elements equals or exceeds 0.20 per cent the metal shall contain not less than 0.17 per cent copper and not more than 0.06 per cent sulphur. If the total of these five elements is less than 0.20 per cent and sulphur is not greater than 0.04 per cent the presence of copper is optional.

(b) The base metal shall be uniformly coated with a good quality of zinc and the surface of the coated metal shall be of such nature that the primer specified will adhere firmly. The zinc coating shall be applied by the hot dip process and heat-treated after coating in such a manner as to give a tight dull coat which will not peel nor flake on the outside of a bend when bent down flat. The dull coated surface of the sheet shall have the characteristics of a matte and shall be free from bright or glossy spangle.

8. Reflector Units

(a) Reflector units shall conform to Specification 15633.

(b) Reflector units, assembled in signs which carry a legend, shall be colorless.

(c) Reflector units, assembled in marker sign which carries no legend, shall be canary yellow.

(d) Reflector units having an exposed diameter of 0.40 to 0.50 in. shall be used in letters 4 inches in height. Reflector units having an exposed diameter of 0.590 to 0.688 in. shall be used in letters and numerals 5½ inches in height and also in marker sign. *R-8-d.

* Section 15533. Alternate requisites.

(e) Reflector units shall be held in a fixed relation to the aperture with their axes normal to the face of sign.

(f) Reflector units shall be held in position in front plate by means of an intermediate plate. The intermediate plate shall be readily removable and replaceable without the use of tools and when removed shall release reflector units.

(g) Reflector units shall project not more than ¼ in. outside of aperture.

(h) A durable waterproofing gasket of non-corrosive material shall be used between reflector units and front plate.

9. Design, Sheet Steel Signs

(a) The front, back, and intermediate plates shall be No. 16 U. S. Standard Gauge (0.0625 in.).

(b) Reinforcing metal parts or supporting plates used in back of signs shall be ¼ inch in thickness.

(c) The front and back of sign shall be flanged to a depth of not less than ¾ in.

(d) Flanges shall be welded at corners.

(e) The front plate shall be slightly larger than the back plate so that it will freely telescope over the flanges of the back plate.

(f) The front plate shall have the legend of the sign embossed upon it. The embossed numerals and letters shall be raised not less than 0.085 in. nor more than 0.125 in.

(g) The dimension, inside, between the front and back plates shall be such as is necessary to meet the requirements of this specification and the particular reflector unit assembled in the sign.

(h) The front plate shall be attached to the back plate by bronze screws of special design which cannot be removed with an ordinary screw driver. If nuts are used they shall be so designed that they cannot be removed with ordinary pliers, wrench, or screw driver.

10. Painting, Cast-Iron Signs

(a) Painting shall be in accordance with Specification 12022.

(b) Cast-iron signs shall be given a coat of red oxide metal primer.

(c) Two coats of permanent white paint shall be applied over the priming coat. *R-10-c.

* Section 15533. Alternate requisites.

(d) Two coats of black paint shall be applied to letters and numerals.

11. Enameling, Sheet Steel Signs

(a) Metal shall be thoroughly cleaned in order to secure a perfect surface for painting.

(b) One coat of suitable iron oxide primer of the long oil type shall be applied to all surfaces.

(c) Subsequent to the priming coat on signs bearing a legend, all surfaces shall be given three coats of black eggshell finish high grade synthetic enamel. *R-11-c.

* Section 15533. Alternate requisites.

(d) Subsequent to the priming coat on marker sign bearing no legend, all surfaces shall be given three coats of semi-gloss permanent lemon yellow high grade synthetic enamel.

(e) Three coats of semi-gloss permanent white high grade synthetic enamel shall be applied to the embossed portion of the sign.

(f) Materials used in the enamel shall be such that premature chalking will not take place. Each coat shall be thoroughly dry before subsequent coat is applied.

(g) The finished design shall be clear cut and sharp and the lines even and true.

(h) The finish produced on the signs shall be a tough flexible coating, free from cracks, shrinkage, wrinkles, blisters, or other blemishes and shall withstand the following tests:

1. The finish shall not chip nor flake when tested with the point of a knife.
2. The finish shall withstand a gasoline test made by rubbing with a clean white rag soaked in gasoline.
3. The finish shall possess such elasticity and adhering qualities that it will not crack nor separate from the sign when struck a light blow with a hammer.

12. Identification

(a) Inside of sign shall be plainly marked with name of Manufacturer.

13. Inspection

(a) Purchaser may inspect material at all stages of manufacture.
(b) Purchaser may inspect the completed product to determine that the requirements of this specification have been met.
(c) If material has not been accepted at point of production and if, upon arrival at destination, it does not meet the requirements of this specification, it may be rejected, and the Contractor, upon request, shall advise the Purchaser what disposition is to be made of the defective material. Contractor shall pay all freight charges.
(d) If Purchaser is to make inspection at point of production it shall be so stated.

14. Tests

(a) Tests may be made at point of production, or on samples submitted, and may also be made at destination.
(b) Contractor shall give the Purchaser sufficient notice of time when material will be ready for testing.
(c) Contractor shall provide, at point of production, apparatus and labor for making required tests under supervision of the Purchaser.
(d) If tests are to be made at point of production, the Purchaser shall so state and also indicate which of the tests herein specified are to be made and what portion of the material shall be tested.

15. Packing

(a) Material shall be so prepared as to permit convenient handling and to protect against loss or damage during shipment.

16. Marking

(a) Purchaser's order, requisition and package number, name of Consignor, and name and address of Consignee, shall be plainly marked on outside of package.
(b) Detail list of loose pieces, containers and their contents shall be furnished for each shipment. Where carload shipments are made, routing and car identification shall be shown.
(c) Where carload shipments are made, name and address of Consignee may be omitted.

17. Warranty

(a) Contractor shall warrant the material covered by this specification to be free from defects in material and workmanship under ordinary use and service, his obligation under this warranty being limited to making, at point of production, any part or parts to replace those which shall be found defective within two years after shipment to the Purchaser. This warranty shall not apply to any apparatus which shall have been repaired or altered in any way by anyone other than the Manufacturer thereof, so as to affect, in the Contractor's judgment, its proper functioning or reliability, or which has been subject to misuse, negligence or accident.

15533. Alternate Requisites

R-8-d

When specified by the Purchaser, reflector units having an exposed diameter of 0.400 to 0.563 in. may be used in letters 4 inches in height; reflector units having an exposed diameter of 0.562 to 0.688 in. may be used in letters and numerals 5½ inches in height, also in marker sign, but those used in 4 in. letters shall be smaller than those used in 5½ in. letters, numerals and marker sign.

R-10-c

When specified by the Purchaser, a ½ in. black border may be used.

R-11-c

When specified by the Purchaser, a ½ in. white border may be used.

A

REPORT OF COMMITTEE VI—BUILDINGS

A. L. SPARKS, *Chairman;*
A. L. BECKER,
G. A. BELDEN,
ELI CHRISTIANSEN,
A. C. COPLAND,
F. B. DOOLITTLE,
W. T. DORRANCE,
R. L. EHRLICH,
HUGO FILIPPI,
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A. C. IRWIN,
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F. R. MICHEAL,
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E. W. NIBLET,
G. A. RODMAN, *Vice-Chairman;*
J. W. ORROCK,
*F. L. RILEY,
O. M. ROGNAN,
A. B. STONE,
ARTHUR T. UPSON,
C. L. WENKENBACH,
O. G. WILBUR,
Committee.

* Died September 1, 1932.

To the American Railway Engineering Association:

Your committee respectfully presents herewith report covering the following subjects:

1. Revision of Manual. No changes are recommended.

2. Preparation of Specifications for Railway Buildings (Appendix A). It is recommended this subject be reassigned for continued study.

3. Remodeling freight houses for accommodation of truck door-to-door delivery of freight, collaborating with Committee XIV—Yards and Terminals (Appendix B). It is recommended that this subject be reassigned.

4. Bus terminal buildings, isolated and in conjunction with railway stations, collaborating with Committee XIV—Yards and Terminals (Appendix C). It is recommended that this subject be reassigned.

5. Application of stainless and rust-resisting steels to building construction (Appendix D). It is recommended that this subject be reassigned.

6. Vermin and rat-proofing buildings (Appendix E). It is recommended that this subject be reassigned.

7. Modern methods of heating small railway buildings showing comparative advantages of warm air, hot water, steam and possibly fan unit systems (Appendix F). It is recommended that the report on this subject be received as information and the subject be discontinued.

8. Design and construction of modern fruit and produce terminal buildings, collaborating with Committee XIV—Yards and Terminals (Appendix G). It is recommended that report on this subject be received as information and the subject be discontinued.

9. Relative merits of wood and fireproof roof structures which should include wood, hollow tile fireproofing, concrete and cement tile, etc. (Appendix H). It is recommended that this subject be reassigned.

10. Use of materials other than brick, stone and cement in exterior and interior walls, partitions, floors and ceilings of buildings with a view to:

(a) Fire resisting qualities.
(b) Less space occupied by materials of construction.
(c) Better heating conditions.
(d) Quieter interiors.
(e) Reduction in size and weight of framework and enclosures.
(f) General reduction in cost of construction (Appendix I).

It is recommended that report on this subject be received as information and the subject be discontinued.

11. Causes of dust explosions in grain elevators and methods for obviating the hazard (Appendix J). It is recommended that this subject be reassigned.

Respectfully submitted,

THE COMMITTEE ON BUILDINGS,
A. L. SPARKS, *Chairman.*

Bulletin 354, February, 1933.

Appendix A

(2) PREPARATION OF SPECIFICATIONS FOR RAILWAY BUILDINGS

F. R. Judd, Chairman, Sub-Committee; E. L. Haberle, A. C. Irwin, O. M. Rognan.

The Committee submits for publication in the Manual, Specification for Hydraulic Elevators—Baggage or Freight—previously published in the Proceedings as part of Appendix D, Section 28, pages 1215 to 1224, both inclusive, of Bulletin 323, and Vol. 31, Proceedings, 1930.

The Committee also submits for publication in the Manual, subject to the following revisions, Specifications for Steel, Brick and Reinforced Concrete Chimneys, with addenda for draft gages, pyrometer and lightning protection, all as previously published in the Proceedings as Appendix A, pages 406 to 424, both inclusive, of Bulletin 343, and Vol. 33, Proceedings, 1932.

The revisions are:

1. Steel Chimney Specifications, page 407, Unit Stresses, add the words "lb. per sq. in." after the unit stresses given in the table for concrete in compression and shear, also reinforcing steel in tension and bond.
2. Reinforced Concrete Chimney Specifications, page 415, Unit Stresses, omit the words "lb. per sq. in." which appear after the ratio moduli of elasticity.
   Insert after the words "Ratio moduli of elasticity," the words "for 2000 lb. concrete" and immediately below this line insert another line reading, "Ratio moduli of elasticity, for 3000 lb. concrete..10."

The following specification, Section 29, Electrically-Operated Freight or Baggage Elevators, has been prepared and is submitted at this time for publication in the Proceedings as information and for criticism.

The Committee is holding in abeyance for further criticism and consideration Specifications for Asphalt Impregnated Felt Roofing over Wood or Pre-cast Gypsum and over Concrete or Poured Gypsum, Section 10-D, Types D-1 and D-2 respectively, which were published in Bulletin 323.

The Committee now has in course of preparation Specifications for Wood Door and Wood and Metal Frame, Window Screens, and two additional Specifications for Asphalt Impregnated Asbestos Felt Roofing to be submitted at a later date.

Your Committee has been approached by the Wrought Iron Industry and also by the Brick Manufacturers' Association regarding the preparation of additional chimney specifications, which would permit the use of wrought iron and reinforced brickwork to be used as an alternate to steel and brick chimneys. The action to be taken in response to this request is being considered by the Committee.

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 29

ELECTRICALLY-OPERATED FREIGHT OR BAGGAGE ELEVATORS

1. General

The Contractor shall furnish all labor, materials, tools and equipment to entirely complete the electrically-operated freight or baggage elevator system as hereinafter specified and as indicated on drawings.

The Contractor shall furnish and install under his lump sum price—cars, car covers, doors, guides, counterweights, hoisting machinery, machinery supports, car safeties, control panel, operating switch, signal system and all other equipment necessary to make a complete and finished system in running order, as herein described and specified.

2. Checking Drawings

The Contractor shall check all drawings of his own work and of work with which his work engages. He shall report all discrepancies before starting the work, and no allowance will be made for such errors and discrepancies after the work has been started. The Contractor shall submit a layout of the system and complete details of all parts showing equipment to be installed. Drawings shall conform to rules and regulations of the local and state authorities, and, if necessary, be submitted to such authorities for approval.

3. Laying Out Work

Dimensions on drawings shall be verified on the site of the work by the Contractor, and he shall assume all responsibility for their accuracy.

4. System

The system shall consist of .... traction type elevator and shall be provided with the necessary equipment to meet the requirements hereinafter specified:

Each elevator shall be installed in hatchway shown on accompanying drawing. Each elevator shall lift a load of .... pounds (........), exclusive of the weight of the car, at a speed of..................feet (........) per minute. The capacity shall be shown in large letters in a prominent position on the car. The travel of the car platform shall be ....feet (........). which distance is between .... and .... which are the lower and upper terminals.

5. Car Platform

The car platform shall be of first grade maple supported on a steel frame, shall measure at least .... feet (........) long overall, and shall be designed for a load of 200 lb. per sq. ft. The sides shall be protected with extra strong rigid guards of U.S. gauge No. 12 steel plates and 2-inch angles to a height of at least 8 feet. Clearance between car platform and underside of head beam shall be not less than eight (8) feet.

Upon the steel stringers of platform shall be laid a heavy yellow pine floor upon which shall be laid tongued and grooved and matched 1⅝ inch maple flooring laid so that trucking will be in direction of grain so arranged that the maple flooring may be easily renewed. The flooring shall be protected underneath with No. 12 U.S. gage sheet metal.

6. Car Cover

The car cover shall be constructed of steel wire mesh not larger than 1½ inches by 3 inches on a reinforced frame. The wire shall be No. 9 U.S. standard gage or larger. The car cover shall be set back 6 inches from the ends of the hatchway, and equipped with hinged sections at entrance ends at least 18 inches from the edge of the car.

7. Car Frame

Car frame shall be of wrought iron or steel, and be capable of withstanding without undue distortion any stress that may be induced, either by eccentric loading or by the action of the buffers.

Guide shoes shall be provided to insure quiet running. The loading end of the platform shall be provided with a heavy angle or channel iron nosing designed to withstand loading of 200 lb. per sq. ft.

8. Hatchways and Shaft Enclosure

The size of the hatchway and shaft enclosure shall be as shown on drawing but some slight modification may be made if the Contractor should consider it necessary. Contractor shall state in his proposal whether or not such changes will be necessary. The hatchway and shaft enclosure will be constructed by another contractor, but the elevator contractor shall submit drawings of the apparatus he proposes to furnish within one week after he has received notification to commence work, showing details of openings or other items which he will require. He shall also show the space required for elevator doors, guides, counterweights, hoisting machinery, control board and all other apparatus requiring additional space, including the space required for over-run, and pit dimensions required in locality where elevator is to be installed.

9. Hoisting Machine

The hoisting machine shall be of the worm gear traction type with heavy bed plate for overhead installation. The worm and shaft shall be forged in one solid piece and the gear shall be phosphor bronze shrunk on and securely bolted to the driving spider. The worm and gear shall run immersed in oil and free from vibration. The thrust bearings on the worm shall be of the ball bearing type. The driving sheave shall be grooved for the required number of ropes. All bearings on the machine shall be lubricated by means of a satisfactory lubricating system. Bearings of the self-oiling type, either oiled by means of chain or ring oilers or by means of a splash system will be given preference. A magnet brake, spring actuated, shall be provided on the worm shaft of sufficient power to start and hold the car under any possible service. The brakes shall be instantly applied when released by the magnet, the circuit of which shall be opened by the limit stops at both limits of travel, by the safety switch on the car, by the overload circuit breaker governor switch, or when the car is being stopped in ordinary service stops.

The motor used on the hoisting machine shall be of .... make or approved equal, of ample size to operate the elevator under full load and speed for two continuous hours without exceeding a temperature rise of 40 degrees Centigrade above the surrounding temperature. This hoisting machine shall be designed in accordance with good engineering practice and shall be mounted on steel beams provided by this Contractor.

10. Overhead Sheaves

If overhead deflector sheaves are required, they shall be of design to be pressed on shaft and shaft shall be provided with self-aligning babbitted bearing boxes. The lubrication of these bearings shall be in conformity with the method used on the hoisting machine.

11. Lifting Cables

Lifting cables provided in connection with this installation shall be of ample size for the support of the car and counterweight. Equalizer shall be provided to equalize the tension on the cables. These cables shall be of special traction type as manufactured by the .... Company, or approved equal. The number of lifting cables, together with the specifications of same, shall be included in the proposal submitted by this Contractor.

12. Counterweights

Suitable counterweights shall be provided for this installation, these counterweights to be of sufficient weight to compensate for the weight of the car, plus 40 per cent of its rated capacity. Counterweights shall be of sectional cast iron set in structural steel

frame provided with suitable guide shoes and they shall be designed in accordance with good engineering practice.

13. Guide Posts and Guides

The guide posts shall be tees of open-hearth steel, machined or die drawn, uniform, straight and finished, connected by tongued and grooved matched joints, battened with heavy fish plates with through bolts. They shall be so arranged and planed as to provide rigid guides with smooth sliding surfaces. The minimum weight of guide posts acceptable for the car shall be .... pounds per linear foot and the counterweight .... pounds per linear foot. The car guides shall be stiffened by channel iron bolted to the guides by fitted bolts, and necessary backing and supports for guides shall be furnished and installed. All guides shall be anchored by steel brackets embedded in shaft walls during construction, or brackets fastened by through bolts. The maximum distance between guide supports shall be ten (10) feet. Contractor shall show on detailed drawings, submitted for approval, method of supporting guides.

14. Control

The control shall be of the semi-magnet type controller equipped with circuit breaker and reverse phase and phase failure protection. This controller shall be of make manufactured by .... Company, or approved equal. This control shall be operated by hand rope control.

15. Operating Device

Car switch shall be provided if elevator travels a greater distance than three floors. Elevators travelling three floors or less may be equipped with hand rope control consisting of ½-inch wire tiller rope provided with button stops which shall automatically bring the car to a stop at the upper and lower limits of travel. If hand rope control is used, it is to be located at the outside of the side guards, and it is to be protected to the height of a baggage truck. Hand rope control is to be provided at both ends of the car. Hand rope is to be constructed of phosphor bronze of ...., of approved make. A framed set of prints showing the full wiring connections shall be provided in the pent house.

16. Buffers

The car platform at the lower terminal shall be sustained upon buffers of springs or oil compression type of proper strength and stroke for speed specified. Contractor shall state in his proposal what type of buffers he proposes to furnish.

17. Elevator Doors or Gates

Elevator doors shall be designed to close the entire opening in the shaft enclosure and shall be as wide as the distance between car guards. Each door shall be in two sections, constructed of No. 10 U.S. gage steel plates riveted to 1½-inch angle frame with two cross braces of 1¼-inch tees. Door guides shall be of steel well anchored to the shaft enclosure. Each doorway shall be equipped with an approved type of trucking plate.

Elevator doors at the top and bottom landings shall be full automatic, that is, they shall open as the car approaches and close as the car departs. At the intermediate landings the doors shall be semi-automatic, that is, they shall be opened by hand and close automatically. Both sections of the doors shall lower below the floors into the shaft or pit, unless the shaft design permits half of the door to rise and the other half to lower in the shaft. Contractor shall furnish and install all necessary equipment for doors and shall submit for approval detail drawings showing construction and method of operation.

18. Governor and Safety Device

Elevator shall be provided with safety device on the car of proper construction to stop and hold the car under full load and speed. This safety device shall be actuated by a governor located over the hatchway. The governor is to be equipped with wire cable and it is to be designed to operate in accordance with good engineering practice.

19. Limit Switches

Limit switches shall be provided at both top and bottom of the hatchway, designed to stop the car at both limits of travel.

20. Safety Switch

Safety switch with hand reset shall be provided either on the safety device or overhead governor to interrupt the circuit and apply the brake whenever safety device is placed in action.

21. Foundations and Supports

Steel beams required for the support of the overhead machinery shall be provided by the Contractor. He shall also provide a 3-inch tongued and grooved plank flooring extending the entire area of the pent house. If necessary, this flooring is to be provided with a trap door to permit access to the machinery.

22. Lubricators

Automatic lubricators are to be provided for the lubrication of the car and counterweight guides.

23. Screens and Ladders

There shall be provided under the overhead sheaves a suitable wire mesh screen capable of supporting a minimum weight of 500 pounds. If necessary, there shall also be provided a steel ladder constructed of flats and rounds extending from the high point of the car cover to the pent house floor.

24. Electrical Equipment

The electrical equipment shall be designed to suit the current which will be delivered to the service box in the building and this Contractor shall make the necessary connections to this point. The current available at this location shall be ascertained by the Contractor. All material furnished shall be subject to the approval of the Electrical Engineer before final acceptance. The motors to be furnished shall be of............. make, or approved equal. Automatic switchboard to be furnished shall be of......... .... make, or approved equal. Contractor shall include in his proposal the manufacturers' names and catalog numbers of all electrical material he proposes to use in this installation. Wiring to be used on this installation shall be .... as manufactured by the ...., or approved equal. Conduit shall be ...., or approved equal. Safety switches shall be of the latest improved type of .... make, or approved equal. All wiring shall conform to the requirements of the National Board of Fire Underwriters. All starters and regulators shall be fully enclosed in steel cabinet equipped with swing doors and suitable lock.

25. Signal System

A suitable method of signaling shall be furnished and installed by the Contractor. This signal system shall consist of electric bells, one located at the upper landing and one

34. Guarantee

The Contractor hereby guarantees all material, workmanship and the successful economical and safe operation of the elevators for a period of twelve months after the completion of same, and agrees to repair or replace at his own expense any part of this apparatus which may show defects during that time, provided such defects are, in the opinion of the Engineer, due to imperfection in material or workmanship, as specified, and not caused by carelessness or improper operation. He guarantees also that each of the elevators will be capable of lifting the live load specified herein, exclusive of weight of car, at the specified speed. The checking and approval of shop drawings by the Railroad Company, or any omission in these specifications or the drawings accompanying same, do not relieve the Contractor of his obligation to install the elevators complete in every respect, and to fulfill his guarantee.

35. Inspection

The Contractor shall furnish at his own expense necessary certificates of inspection for the entire elevator plant put in under these specifications good for twelve months from date of final certificate from the Engineer.

36. Final Inspection and Test

At the completion of the work the Contractor shall test the elevator and shall arrange for final inspection. The test shall be made during the final inspection and shall consist of subjecting the elevator plant to 60 minutes running as in service conditions with the loads and speeds hereinbefore set forth, and shall consist of such other tests as may be deemed necessary by the Engineer to show compliance with these specifications. These tests shall be made by and at the expense of the Contractor, and under the direction and supervision of the Engineer. The Contractor shall furnish all the labor, instruments and weights necessary to make these tests.

37. Laws and Ordinances

Contractor shall be solely responsible for any violations of laws or ordinances and all workmanship and material shall comply in all respects with requirements of such laws. He shall save the Railroad Company free and harmless from any penalty attaching to the violation of any legal regulations affecting his work and all such regulations are hereby incorporated as a part of these specifications. If there are any conditions shown on the drawings or mentioned in the specifications that conflict with Federal, State, City, or Municipal laws and ordinances, the Contractor shall so state in a letter accompanying his proposal. Failure to call the Railroad Company's attention to any discrepancies shall make the Contractor liable for any expense encountered in complying with aforementioned laws and ordinances.

38. Cleaning

At the completion of the work, the Contractor shall remove all construction equipment, scaffolding, staging, erection platforms and all surplus material from the premises, leaving the premises in a clean and acceptable condition. If any equipment or débris is not removed promptly, such material may be removed at the expense of the Contractor.

39. General Conditions

All materials entering into the work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

The general conditions given in Section 1 of this specification shall be considered to apply with equal force in this section of the specification.

Appendix B

(3) REMODELLING FREIGHT HOUSES FOR ACCOMMODATION OF TRUCK DOOR-TO-DOOR DELIVERY OF FREIGHT

A. C. Copland, Chairman, Sub-Committee; A. L. Becker, R. E. Mohr, E. A. Harrison.

Members of Sub-Committee have conferred with members of Committee XIV and wish to report progress, and request that subject be re-assigned for further study.

Appendix C

(4) BUS TERMINAL BUILDINGS, ISOLATED AND IN CONJUNCTION WITH RAILWAY STATIONS

O. G. Wilbur, Chairman, Sub-Committee; C. L. Wenkenbach, E. W. Niblet, J. W. Orrock.

The Sub-Committee has collected some information, but desires that subject be continued for further study.

Appendix D

(5) APPLICATION OF STAINLESS AND RUST RESISTING STEELS TO BUILDING CONSTRUCTION

J. W. Orrock, Chairman, Sub-Committee; F. B. Doolittle, Hugo Filippi, A. B. Stone.

The Committee reports progress and desires that subject be reassigned for further consideration.

Appendix E

(6) VERMIN AND RAT-PROOFING BUILDINGS

A. H. Morrill, Chairman, Sub-Committee; Hugo Filippi, A. C. Irwin, W. T. Dorrance.

The Committee reports progress and desires the subject be re-assigned for further study.

Appendix F

(7) MODERN METHODS OF HEATING SMALL RAILWAY BUILDINGS, SHOWING COMPARATIVE ADVANTAGES OF WARM AIR, HOT WATER, STEAM AND POSSIBLY FAN-UNIT SYSTEMS

Eli Christiansen, Chairman, Sub-Committee; F. L. Riley, W. T. Dorrance, C. D. Horton.

Introduction

We are sometimes confronted with unusual heating problems for small railway buildings where steam connections cannot be made with central power plants and where, in some cases, the possibility of large fire loss, the restricted space, inaccessible location or other conditions make undesirable the use of individual coal-fired boilers or furnaces. In other cases operating conditions may make unusual types of heating apparatus necessary.

Much progress has been made in the last ten years and is still being made in the efficiency and convenience of heating apparatus. Although the cost of fuel is one of the major items of railway operating expense, it should not necessarily be the controlling factor in the selection of small heating plants, for the unit cost is generally low, so

that total fuel cost for small plants may be relatively unimportant as compared with the cost of labor for tending the fire and for maintenance.

Then, too, uniform heat provides for greater efficiency of employees and fewer lay-offs for colds and sickness. In railway stations, the comfort of passengers and shippers will go a long way toward molding public sentiment and creating good-will.

Many factors should be considered in selecting the type of heating apparatus; among which are such items as:

1. Volume of space to be heated.
2. Kind of fuel most easily available.
3. Heater accessible or inaccessible to public.
4. Whether to be fired by janitor or others.
5. Whether or not space is available for fuel and ash storage.
6. Unsightly and unsanitary condition produced by stoves.
7. Risk of fire from overheated fire bowls, stove pipes, or chimneys.
8. Whether or not heat is to be maintained day and night.
9. Whether a uniform heat throughout the day and night or a quick hot temperature is required.

Heating apparatus for small buildings may first be divided into three general classes:

(A) Individually coal fired stoves or heaters, operated by the occupants of the room in which the heater is located.
(B) Systems heated with furnaces or boilers fired by janitors or regular attendant.
(C) Electric, gas or oil-burning heaters regulated automatically without attendant.

CLASS A

Notwithstanding the progress made in recent years, the heater most commonly used in small railway buildings today is the same three piece cast iron stove used forty years ago. This is no doubt due to low first cost, simple construction, replacements for which may be cast in railroad foundries, and due to the fact that such equipment does not require skill for either operation or maintenance.

For switchmen's shanties, hump riders' houses and other places where a quick hot fire is desirable to warm men constantly dodging in and out of bitter cold weather, probably no better method has yet been devised.

For the comfort and accommodation of the traveling public who are accustomed to much different systems at home and in their places of business, such stoves are inappropriate, when more efficient equipment can be had at less operating expense.

Where stove heat is desirable, the modern base burner or circulating heaters are highly efficient as compared with the older types and require much less fuel and less frequent attention. These stoves have heavy cast iron fire pots and domes are enclosed in an outer casing of steel or enameled iron so arranged as to draw cold air from the floor at the bottom, and expel warm air through openings at the top, thus creating a constant circulation and heating of the air in the room. Care should be taken to select stoves of ample size so that only in the coldest weather will it be necessary to keep the drafts open.

Though this type of heating system may be installed and operated at low cost per unit, it has its limitations and when two or more stoves are required for the same building, a furnace or boiler generally costs less for operation.

In railway stations the unsightly appearance is often objectionable.

It is difficult to keep coal and ashes off waiting room floors especially where it is possible for patrons to open fire or ash doors. There is also danger of children being burned and danger of irresponsible persons pulling fire out on to floor and setting fire to the building.

There is also danger of stove pipes becoming overheated when drafts are opened and neglected. Building fires are sometimes caused by overheated fire bowls, bursting and letting fire fall out.

CLASS B

Class B includes warm air furnaces, steam and hot water systems.

Warm Air Furnaces

The various classes of warm air furnaces can be divided into the warm air furnace with hot air outlet and single recirculating duct, and the warm air furnace with hot air supply and return ducts to the various rooms. The warm air furnace with single hot air outlet and return is suitable for small buildings, arranged to permit free circulation of air from the furnace to all parts.

The warm air furnace with hot air supply and return ducts to the various rooms is more expensive than the other type of heater, but has the advantage of supplying heat to separated rooms and furnishes a more positive method of control by adjustable registers in each room. Any of these types of heating can be combined with the use of a water jacket and the installation of a small amount of direct radiation to rooms at remote distance from the furnace, which are the hardest to heat. The construction cost of a hot air heating system is ordinarily less than for steam or hot water and the hot air furnace lends itself better to the installation of evaporators for increasing the humidity.

In some systems, air is taken from the outside, as well as from the inside of the building, providing both heat and ventilation. The greatest disadvantage is that the circulation depends upon natural draft; i.e., it depends on the difference in weight between the air inside the flues and the air outside of the flues, so that the force providing the circulation in the flue is always small, making it difficult to heat rooms at a great distance from the furnace on the windward side, limiting the horizontal flues to a distance of not to exceed 15 feet.

The method of controlling heat distribution in a warm air system is not as positive as with steam or hot water, and there is an objectionable amount of dust, ashes and gases circulated to the spaces heated. However, one decided advantage over steam is that even though the plant has been banked, there is always a little heat being carried to the various rooms during the night providing for a more gradual drop in temperature than with steam.

In buildings used for offices or where a number of people are employed, humidity is an important consideration, as it lowers the temperature at which work may be done in comfort, increases the efficiency of the occupants, and decreases the time lost due to illness.

In small buildings, furnaces with certain refinements such as electric fan for promoting circulation, improved evaporators for controlling humidity and better constructed combustion chamber for reducing circulation of dirt and gases, promise to become more popular and offer advantages in the control of humidity over steam or hot water heating systems, with radiators in each room.

Steam Heating Systems

This type of heating has been in general use for many years and gives very good results. These systems cost more than either stoves or furnaces, but afford more positive method of heat circulation than either stove, furnace or hot water boiler, unless a circulating pump is used on the hot water system which would not ordinarily be justified in a small building.

From a standpoint of ventilation direct steam heating without other means of ventilation is not as desirable as warm air furnace. Mechanically, however, it has many advantages as the modern radiator is easily adaptable to almost any location in the room and is not easily affected by winds. The circulation is positive and a distant room can be as easily heated as a room close to the boiler. There are several types such as one-pipe gravity and two-pipe gravity vacuum vapor and other combinations, including direct radiation, indirect radiation, etc. This system by thermostatically controlled valves at the radiators can be made to maintain almost any desired room temperature. But this form of heating does not offer as satisfactory method of controlling the building temperature at the boiler as the hot water system; however, with the use of vapor specialties, the system can be operated at very low pressures and the temperature of rooms controlled by valves at each radiator which regulate the flow of low pressure steam. Vapor systems make use of steam at pressures slightly higher than atmosphere, and in some cases below.

A well designed steam heating system developes from 60 per cent to 70 per cent of heat in fuel.

Hot Water Heating Systems

This type is quite similar to steam, but the heating medium being at a lower temperature, requires more radiating surface. It has some of the advantages of steam and other advantages that steam heating systems do not have. Due to the larger size pipe necessary, the first cost is somewhat greater, but they are more efficient due to the fact that a uniform temperature of water is more easily maintained. There are a number of different types of hot water heating systems; such as direct hot water, up feed, one-pipe system, and also overhead system pressure or closed system, as well as open systems of hot water heating.

This type of heating is in some ways better than steam because temperature radiating surfaces can be easily controlled and can be anywhere from room temperature to 190 deg. or even higher in certain forms of hot water systems.

As to efficiency, this type is practically the same as steam, as it develops 60-70 per cent of the heat in fuel. One of the disadvantages in comparison to steam is that it cannot be made to respond as quickly to sudden changes in demand for heat.

Combination and Indirect Systems

Systems utilizing steam and hot water with natural circulation of cold air around warm radiators have the advantage over hot air that each room has a separate source of heat, the system is not so easily affected by wind, no dust or gas is carried to various rooms, and the source of heat is independent of position of boiler. This type is used for either steam or hot water with almost equal advantage, except in the case of water careful installation is required so the circulation is not stopped, resulting in frozen radiators.

Oil and Gas Fired Heating Plants

Oil and gas are adaptable to all forms of heating (stoves, furnaces or boilers). In localities where available at reasonable costs, they should be more desirable, are cleaner, require less attendance and tend to labor-saving, eliminate disposal of ash and make for much neater and cleaner room.

In selecting an oil burner, care should be taken to select one that is adaptable to the boiler so as to be able to use a reasonably cheap grade of oil, No. 3 or below. It should be as fully automatic as possible with simplicity of adjustment. Ordinarily, oil is cheaper than gas, except in locations near natural gas fields.

CLASS C

Automatically controlled heating systems, which require no janitor or special attendant, may include unit fans heated with steam from a central boiler plant, unit fans heated with gas or electricity, electric heaters, direct fired gas heaters, and direct fired oil heaters.

Fan Units

Fan units have been used for sometime very successfully. They are operated electrically, using steam for radiation, and in some cases electric resistance. Where large spaces are to be heated, it can be done more economically with unit steam heaters than with radiators.

The all-electrical type is more costly to operate but is very convenient for places where it is not practicable to install a boiler. The heat output of unit heaters is ordinarily regulated by thermostat control of the motor, steam pressure being allowed to remain on the heating element at all times, except when steam is cut off entirely.

A good arrangement in buildings with high ceilings is to control the flow of steam to the heater by automatic control valves and permit the fan to run continuously in order to reduce the accumulation of excess heat in the area above the working zone. In installation where steam pressure is lowered for use in unit heaters by passing through a reducing valve, the heating element should be designed for a working pressure not lower than the initial pressure before passing through the reducing valve due to possibility of the full pressure being applied. In a small heating system, care should be exercised in selecting size of unit heater and determining method of control as a few large units with fan control only would cause the boiler load to fluctuate too much.

There are some disadvantages in this form of heating due to the noise of the fan, but in such small units as would be required for small railway buildings probably this could not be considered a very serious disadvantage. There are fan units built of standard type cast iron radiators, with fan blowing between the sections. These radiators can be installed in enclosed cabinets directly on the floor. There is also a new form of unit heater which is entirely electrical and does not require steam. This form of heating has considerable advantage over all other forms, especially for the heating of small areas, where open fires are not permissible and where other kinds of fuel could not be handled.

Direct Fired Gas and Oil Heaters

Gas steam radiators are used in small buildings in the natural gas belt and are successful where proper ventilation is provided and where heaters are connected to flues for discharge of fumes. Special care must be used in extreme cold weather to keep radiators from freezing when not in use.

Gas fired circulating heaters and oil fired circulating heaters using kerosene, or light oils are becoming popular in some localities especially in southern territory where the heating season is not long and where heat is sometimes required for only a few hours each day. These heaters are made in several stock patterns and sizes, capable of delivering from 20,000 B.T.U. to more than 100,000 B.T.U. per hour.

Being easily equipped with automatic thermostatic control, they require very little attention.

Appendix G

(8) DESIGN AND CONSTRUCTION OF MODERN FRUIT AND PRODUCE TERMINAL BUILDINGS

E. K. Mentzer, Chairman, Sub-Committee; F. R. Micheal, L. C. Hinsch, E. A. Harrison.

Introduction

Modern fruit and produce terminal buildings should be designed and built for the service and convenience of both the shipper and buyer and be provided with suitable facilities for receiving, housing, storing, displaying perishable farm and garden products, and for the proper and prompt handling of shipments of fruit, vegetables, and in some cases, butter, cheese, eggs and poultry. Dressed meats, groceries and canned goods may also be taken care of.

One large building housing all departments or separate buildings may be designed and constructed to fit the conditions required, according to the amount of business carried on in that particular locality and made to conform to the local building laws; care being taken to construct in a manner to insure that future expansion and growth of business can be economically provided for when required.

The buildings may be one of the several types of construction:

Type No. 1	Wood frame construction
Type No. 2	Mill construction
Type No. 3	Masonry construction

In a wood frame type of construction, the first cost is usually less, but the maintenance and insurance being high the saving in the end is reduced. This type should be omitted as unsuitable for permanence and fire risk.

Mill type of construction, consisting of masonry walls, wood columns, heavy timber floor beams and thick plank floors, although not fireproof, is such as to retard the progress of a fire and thus afford some measure of protection.

Masonry type of construction, consisting of steel or reinforced concrete frame with walls, floor and roof of concrete, or some other fireproof material, provides greater fire protection, lower insurance rates, durability, freedom from repairs and renewals, as well as being somewhat vermin-proof, and more sanitary.

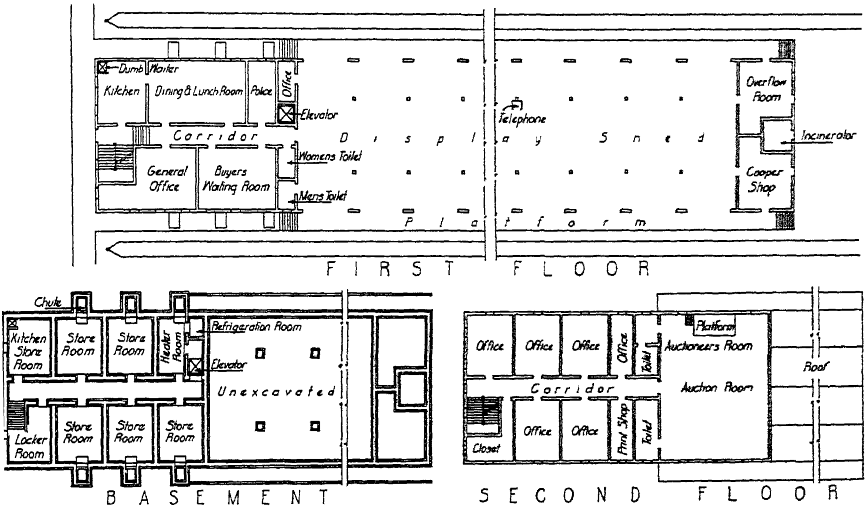
Fire protection is desirable and is best acquired by the installation of sprinkler systems, or by means of fire hose lines, which will tend to lower the insurance rates.

Each of the various products may be handled in one or more independent produce buildings, forming a complete market in itself, with storage, display, sales and office facilities, or separately in the following buildings:

Office and Stores
Display and Private Sale Building
Warehouse, including Cold Storage
Auction and Display Building
Butter, Cheese and Egg Building
Poultry Platforms
Banana Building
Incinerator Plant
Cooper Shop
Heating, Refrigeration and Icing Plant

The size of an individual building may vary from 70 ft. to 110 ft. wide by a length suitable to care for the requirements of the business contemplated. The building should be provided with quarters for the executive offices, as well as for representatives of other railroads, inspection bureaus, and for merchants who may desire accommodation.

Illustrations are shown to further explain the features of a typical fruit and produce building, for explanation of the governing conditions and for elaboration of the explanation.



Typical Fruit and Produce Terminal Building.

The following departments may well be provided if so desired:

Basement:

- Locker and Washroom for Employees
- Storerooms for various kinds of Fruit and Produce
- Room for Egg Candling and Egg Storage
- Cold Storage Rooms
- Kitchen Storage
- Heater Room
- Elevator Machine Room

First Floor:

- General Offices
- Kitchen, Dining and Lunch Rooms
- Buyers' Waiting Room
- Men and Women's Toilets
- Police Quarters (only in large terminals)
- Display Shed
- Cooper Shop
- Overflow Room
- Incinerator Room
- Cashier's Office
- Telephone and Tally Booths

Second Floor:

- Offices
- Storeroom for Records
- Auctioneer's Room and Toilet
- Print Shop
- Public Toilet
- Auction Room

The buildings should be equipped with heating and lighting systems, as well as cooling and refrigerating facilities, if required.

Sufficient floor space should be had for the proper circulation around the products on display and the posts or columns should be located out of the traveled way.

Floors, except those of offices, should be of concrete with a metallic hardener surface and pitch toward floor drains or doors.

Halls and offices should have finished hardwood floors, or concrete covered with linoleum.

Stairs and freight elevators should be provided from basement to floors above.

Doorways should be equipped with rolling steel or vertical lift doors for fire protection and when opened to be about 8 ft. 6 in. to 9 ft. 0 in. high by about 16 ft. 0 in. wide with windows over doors where possible.

Provision should be made to have special doors of a height sufficient to allow the passage of loaded trucks.

Platforms should be about 8 ft. 0 in. wide with canopies over about 12 ft. 0 in. wide at car clearance to protect produce from the weather during unloading and delivery. Canopies should pitch toward building to improve roof drainage.

Additional space suitable for use during winter or inclement weather may be provided under canopies by wholly or partially closing in front and providing with doorways.

The provision made for unloading merchandise from cars with the greatest ease is had by providing the display shed floor at the same level as the car floor. When the cars are released the space may be made use of by trucks and wagons in hauling away merchandise.

As the contents of the cars are unloaded into the house, they are piled in lots, marked and sample boxes of each lot opened and displayed. The buyer, on entering the house, secures a catalogue, printed each day, which shows the various offerings, with the lot number on the display. He looks over the merchandise and, if interested, makes notes in his catalogue. The ringing of a large electric gong notifies all buyers that the sales are about to commence in the auction room. From the inspections and notes made the buyer is enabled to make a bid when the lots he is interested in are called for sale. It is desirable that the time of making deliveries be reduced to a minimum and the commodities removed from the buildings or cars as soon as possible. Rigid rules, benefiting all concerned, should be made and enforced.

A public address system may be installed so that the switchboard operator may call buyers and inspectors from any part of the building to answer telephone calls. Tally and telephone booths should be provided in convenient locations.

The auction room should be spacious for good circulation and required seating capacity. The rostrum should be elevated and provided with desks for clerks. Desks and seats for buyers should be on a floor sloping toward the rostrum so that those present may have a clear view of the auctioneer at all times.

Special care should be given to the acoustical treatment and lighting.

Banana Rooms

Banana rooms are designed to meet two purposes:

1. For the storage and retarding of green fruit with a temperature at around 56 deg.
2. For ripening and holding fruit with a temperature ranging from 56 deg. to 70 deg.

Rooms should be properly insulated with 3 in. to 4 in. of cork so that an even temperature may be had, as otherwise injury to the fruit occurs, whether green or ripe.

Pipe coils, or bunkers, are located at the ceiling with drip pans connecting with the drainage system.

Floors should be made of 3 in. to 4 in. of concrete wearing surface laid on a cork insulation, sloped toward the floor drain or the door.

Joists for the storage of bananas are located at the ceiling about 14 in. on centers, but which are omitted over walking aisles.

Banana hooks are required to be installed on the ceiling fastened to joists 8 in. on centers.

Walking aisles should be from 2 ft. 9 in. to 3 ft. 0 in. wide.

Cold storage doors should be provided.

Poultry Platforms

Poultry platforms should be 16 ft. to 20 ft. wide and at car floor level above the track. Platforms should be covered and supplied with water and light. Supports should be located to minimize interference with trucking and handling crates. Usually space should be provided near the platform for crate storage and cooperage.

Refrigeration

The installation of a refrigeration and air conditioning system is necessary and should be designed especially to meet the local conditions and requirements of the building.

Cold storage rooms should be provided and their size, shape and location determined for their particular use. The various rooms chosen for refrigeration purposes should have the heat loss reduced by means of insulation, thus reducing the refrigeration required.

All low temperature pipe lines should have sufficient insulation to effect economy of refrigeration.

Rooms used for the individual needs for cold storage handling of food products, with the exception of freezer and hardening rooms, should have a temperature range of 32 deg. to 40 deg. Fahr.

Freezer and hardening rooms differ from these rooms in the amount of refrigeration and thickness of insulation with a temperature as low as 65 deg. Fahr. below zero.

These cold storage rooms may be built in any type of building, and in basement, or upper floors.

The principal point is to provide ample air circulation.

Where different temperatures are required, it is well to have smaller rooms built in blocks, rather than one large room, as the unoccupied space may be shut off, thus saving refrigeration.

Economy of space, piping and refrigeration may be had by arranging the rooms in blocks, as the interior partitions between rooms, being held at about the same temperature, will require less insulation than outside walls.

Walls should have high moisture resisting power. Hollow tile walls resist the entrance of moisture better than those of concrete or brick, and also have, on account of their enclosed air spaces, a heat resisting power.

An economical wall would be of hollow tile protected on the outside with a layer of hard brick, and on the inside insulated with cork and plastered.

Air in such spaces carries some moisture which condenses on the colder surfaces next to low temperatures. In closed up spaces, with an accumulation of moisture, rotting out of wood construction would occur, or in case of ceilings, the moisture would drip down through the insulation.

The design of the rooms should not retard or interfere with the circulation as the process of heat interchange by means of the air is essential, the moisture being taken up by the air in circulation and carried quickly to the pipe coils where it is deposited as frost.

If the circulation of air is sluggish, the moisture will condense on the walls and packages, or else remain in the air, causing a damp, mouldy room.

The most effective system for an active circulation is the arrangement of coils, or bunkers, in the upper part of the room for the entire length. The baffles are insulated to prevent sweating and drip.

Overhead single bunkers are suitable for rooms with a height of from 10 ft. to 12 ft. and a width of 16 ft. For wider rooms double bunkers are used.

In rooms having low headroom side bunkers are installed. The maximum width of rooms for a side bunker is 12 ft., greater width requiring bunkers on both sides. These are not as effective as overhead bunkers.

Non-bearing partition walls may be made of 3 in. or more of cork insulation, plastered on each side. This type of wall allows no air space and takes up less space than an insulated partition. False ceilings may be made of this same material.

Windows should not be provided in cold storage rooms, but, if required, should be used as sparingly as possible. Sash should have multiple panes of glass with air spaces between.

A humidifying system should be installed to prevent evaporation losses and drying out of the various products in storage. The proper amount of moisture in the air is determined and maintained by humidity control. This applies more particularly to bananas, some kinds of fruit and eggs.

Floors of cold storage rooms should be concrete over the floor insulation.

TEMPERATURE OF ROOMS FOR VARIOUS PRODUCTS

Fruits (not frozen) except bananas (Limes and lemons slightly higher)	30 deg. to 40 deg. Fahr.
Fresh vegetables	32 deg. to 40 deg. Fahr.
Eggs (not frozen)	29 deg. to 32 deg. Fahr.
Cheese	32 deg. to 42 deg. Fahr.
Fresh Meats	28 deg. to 33 deg. Fahr.
Pork Products	25 deg. to 28 deg. Fahr.
Bananas	56 deg. to 70 deg. Fahr.
Miscellaneous food products: Cereals, dried fruits and vegetables, nuts, canned goods, etc.	32 deg. to 40 deg. Fahr.
Plants, nursery stock and flowers	28 deg. to 32 deg. Fahr.

Drainage

Proper drainage should be installed to insure and maintain sanitary conditions. Drain pipes should be of proper size with all the necessary traps, cleanouts and appurtenances, and all otherwise necessary for a complete system.

Hand holes to have approved covers set flush with floors and a complete cleanout system furnished.

Hose nozzles should be furnished on each floor for flushing the floors of the various rooms when desired.

Heating

A desirable method for properly heating the buildings is by direct steam heating system, or a combination steam and hot air system.

In a combination system, the steam passes through pipes to radiators, or to unit heaters, where the air passes over pipe coils and is distributed at the proper temperature throughout the building by means of electrically operated fans.

The temperature is controlled by the installation of thermostatic regulators.

Unit heaters should be located as far above the floor as space will permit and not obstructing the trucking aisles.

Electric Lighting

Electric lighting should be ample to meet the local requirements. Circuits should be designed to effect economy and switches located in accessible and convenient places.

A system of flood lighting throughout the display shed should be installed.

Extension cords should be provided for lighting the inside of cars in order that unloading may be handled more conveniently and to better advantage.

Appendix H

(9) RELATIVE MERITS OF WOOD AND FIRE-PROOF ROOF STRUCTURES, WHICH SHOULD INCLUDE WOOD, HOLLOW TILE FIRE-PROOFING, CONCRETE AND CEMENT TILE, ETC.

A. T. Upson, Chairman, Sub-Committee; O. M. Rognan, F. B. Doolittle, C. L. Wenkenbach.

Much work has been done on this subject by the Sub-Committee, which has gone into certain phases quite thoroughly; but additional information is being sought and it is desired that the subject be continued for further study.

Appendix I

(10) USE OF MATERIALS OTHER THAN BRICK, STONE AND CEMENT IN EXTERIOR AND INTERIOR WALLS, PARTITIONS, FLOORS AND CEILINGS OF BUILDINGS WITH A VIEW TO:

(a) Fire Resisting Qualities
(b) Less Space Occupied by Materials of Construction
(c) Better Heating Conditions
(d) Quieter Interiors
(e) Reduction in Size and Weight of Framework and Enclosures
(f) General Reduction in Cost of Construction.

E. A. Harrison, Chairman, Sub-Committee; A. C. Irwin, G. A. Rodman, Eli Christiansen, G. A. Belden.

Several new types of material have been introduced to the building trades in recent years with a view to meeting the demands for less expensive construction. In leased quarters where walls and partitions are subject to frequent change and where it is desirable to subdivide gross space into smaller compartments on account of noise, heating requirements, etc., such construction is highly desirable. In existing buildings of limited floor carrying capacities and where no provision was made for the extra weight of partitions, it is necessary that they be constructed of light weight materials.

There is also a demand for inexpensively constructed buildings for small industries located on railway property. Small buildings of this kind are often moved from one site to another or are shifted slightly in their locations to accommodate track changes or improvements.

With a view to making proper allowance for such conditions attention is called to several types in use in different localities. The subject being rather complicated, is set up under sub-headings, each of which will be considered as a separate subject and in the following order:

1. Exterior walls
2. Interior sidewalls
3. Interior fixed partitions
4. Movable office partitions
5. Floors
6. Ceilings

1. Exterior Walls

The most common type of construction is wood frame covered with boarding and usually with an outer covering of shingles, clapboards, stucco or other protective coating.

Another common type is steel frame with outer covering of prepared sheets of some kind, either metal, asbestos or wallboards.

Some of the most common forms of wall covering falling within the scope of this report are:

SHEET METALS: Flat sheets of iron, steel, aluminum, zinc, etc.
Corrugated sheets of iron, steel, aluminum, zinc, etc.
Various formed sheets to imitate clapboards, panel effects or shingles.

Sheet metals coated or insulated with other materials:
Asbestos Protected Metal.
Metal sheets with a wood filler or insulated filler.
Asbestos coated sheets with a fibre board center.

Sheet asbestos, either flat or corrugated.
Various manufactured wallboards, either painted or coated, with stucco.
Metal laths and stucco or plaster coats.
Wood shingles.
Wood clapboards or drop siding.
Glass tiles and corrugated glass are used to a limited extent for exterior walls but are not in general use.

2. Interior Sidewalls

3. Interior Fixed Partitions

These may be constructed of the following:

Wood lath and plaster coat on wood studding.
Metal lath and plaster coat on wood or metal studding.
Wall boards and plaster coat on wood studding.
Gypsum blocks and plaster coat.
Ordinary wood sheathing on wood studding.
Panelled wood wall covering on wood studding.
Cinder blocks, Haydite, clay and similar products.

4. Movable Office Partitions

Light wood frame with veneered wood and glass panels.
Steel frame with single sheet metal panels.
Steel frame with insulated sheet metal panels.
Steel frame with composition board, asbestos cement board and similar panel.
Various proprietary steel partitions made up in sections so as to be readily erected or moved.

5. Floors

Wood floors laid with matched boards.
Wood blocks of various design.
Edge grain laminated wood strip.
Mastic floors on either wood or concrete sub floor.
Sheet covering of cork, leather, asphalt composition.
Tiles of cork, leather, asphalt, rubber.
Steel trough floors with mastic surface.

6. Ceilings

Metal sheets stamped in various designs.
Plaster on metal, wood or steel laths.
Sheathing or matched wood.
Wall boards with thin plaster coat.
Asbestos or insulating boards without plaster coat.

(a) Fire-Resisting Qualities

The use of materials other than those of fire-resistive character is limited by local ordinances and fire underwriters' requirements. The use of non-fire-resistive materials must therefore be limited to those buildings outside of zones denoted as fire zones in cities and to structures on which the owner is willing to accept the fire risk.

The various materials may be grouped as follows:

a1. Combustible materials—walls, floors and partitions.
Wood sheathing, shingles, clapboards.
Wallboards of vegetable fibre.
Wood floors.
Cork, leather, rubber or asphalt sheets and tiles for floors.

a2. Semi-combustible materials for walls.
Wood laths and plaster coats.
Wallboards with a coating of asbestos.
Steel sheets coated with asbestos and bituminous binder.

a3. Fireproof materials for walls and partitions.
Metal lath and plaster coats.
Sheet metal and asbestos board.
Gypsum blocks and plaster coat.
Haydite or cinder block.

a4. Fire resisting materials for floors.
Steel trough floors with mastic wearing surface.
Mastic floors on suitable sub-base.

(b) Less Space Occupied by Materials of Construction

Due to the relatively very thin walls, the commercial materials falling under groups a1, a2, and a3 will all occupy less space than walls of clay products, stone or concrete.

(c) Better Heating Conditions

Any of the materials in groups a1, a2 and a3 will afford some protection against the radiation of heat. Greater insulation may be had by additional layer of fibre board with any of the other materials. Still greater insulation can be obtained by filling the spaces in walls with asbestos or mineral wool—either packed in or blown in under pressure.

(d) Quieter Interiors

Any insulating material is generally sound deadening, especially those of a porous nature and the more resilient substances, so that these materials serve a double purpose and sufficient material for satisfactory heating conditions will serve for sound deadening.

(e) Reduction in Size and Weight of Frame Work and Enclosures

All of the materials in groups a1, a2 and a3 produce light walls of much less thickness than brick, stone or concrete and this is one of the great advantages of these materials.

(f) General Reduction in Cost of Construction

The cost of materials in groups a1, a2 and a3 is generally less than brick, clay, stone or concrete, but the principal saving in the entire structure is from lighter structure and foundation requirements.

Appendix J

(11) CAUSES OF DUST EXPLOSIONS IN GRAIN ELEVATORS AND METHODS FOR OBVIATING THE HAZARD

R. L. Ehrlich, Chairman, Sub-Committee; R. E. Mohr, A. L. Sparks, O. G. Wilbur, E. L. Haberle.

A report on this subject has been prepared, but since it contains information furnished by other organizations, it is necessary to defer presentation until further conference.

The Committee requests the subject be re-assigned for completion.

REPORT OF SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK

A. N. Talbot, *Chairman;*
C. B. Bronson,
John Brunner,
W. J. Burton,
Chas. S. Churchill,
W. C. Cushing,
Robert Faries,
C. W. Gennet, Jr.,
H. E. Hale,
J. B. Jenkins,
Geo. W. Kittredge,
P. M. LaBach,
C. G. E. Larsson,
J. de N. Macomb,
J. V. Neubert,
W. M. Dawley, *Vice-Chairman;*
G. J. Ray,
Albert Reichmann,
H. R. Safford,
Earl Stimson,
F. E. Turneaure,
J. E. Willoughby,

Committee.

To the American Railway Engineering Association:

During 1932 the staff of the Committee has been engaged in a study of the experimental data accumulated in the field and laboratory tests referred to in the report made a year ago and in the preparation of a report on these tests. The reduction of the data, the preparation of drawings and tables, the interpretation of the various groups of facts bearing on a variety of problems, and the formulation of a report presenting the information and findings in acceptable form have been time-consuming. However, it may be said that, on the whole, excellent progress has been made and that the preliminary draft of the Sixth Progress Report will soon be ready to send out to the Committee for their consideration, and it is hoped that the final form of the report will be ready for printing in a summer Bulletin of the Association.

At this time, it may be well to repeat that the accumulated test material includes (1) tests made on the Pennsylvania Railroad at Claymont, Delaware, to determine the stresses in forms of joint bars under the action of electric locomotives running at various speeds up to 90 miles per hour; (2) tests on the Chesapeake and Ohio Railway at Ashland, Kentucky, to determine the stresses, movements and general action of heavy near-symmetrical joint bars under static loading in track, and to determine the depressions, play and stresses in the rail from point to point along the track and other actions that relate to the uniformity or the variability of track; (3) tests on the Missouri Pacific Railroad at Middlebrook, Missouri, on a stretch of GEO track to learn some of the characteristics of the track action in this form of construction; and (4) laboratory experimental work on several forms of rail-joints intended to supplement the field test data and to aid in their interpretation.

Some of the results of the investigation were referred to in the discussion given by the Chairman at the last Annual Convention, which was printed in Bulletin 346 (June, 1932) and in Vol. 33 of the Proceedings of the Association (1932).

Respectfully submitted,

The Special Committee on Stresses in Railroad Track,

A. N. Talbot, *Chairman.*

Bulletin 354, February, 1933.

A REVIEW OF THE PERFORMANCE OF STEEL RAILS IN AMERICAN RAILWAYS

By C. W. Baldridge

The first railways known to history consisted of tracks equipped with timbers for supporting the wheels of the cars, or wagons, used over them. From the wooden rails the search for more durable supports for the wheels has gone through the materials of stone sleepers, cast iron rails, wrought iron rails and, with the invention of the Bessemer process of steel making, to steel rails.

In 1856 the first Bessemer steel rails were rolled, but they were considered unsatisfactory; however, their manufacture was resumed in 1864. A more complete history of Bessemer steel rails is to be found in the Proceedings of the American Railway Engineering Association, Vol. 13, page 845, from which the following is quoted:

"Bessemer rails were rolled in England and tried by many of the railroads, commencing about 1860, and in 1863 a number of trial orders were placed for similar rails in this country. The cost at that time of one hundred to one hundred and twenty dollars ($120.00) per ton, in gold, to which was added the premium of forty or more percent in our currency, forced the railways to use as light a section as possible of the steel. Many of the sections of 56 to 58 lb. per yard, four inches in height with comparatively thick base but thin heads, were imported and tried. The steel rails in places of severe service would outlast ten to fifteen of the best iron rails which could be secured.

Bessemer steel works were inaugurated in this country about 1866.

From the beginning of the manufacture of Bessemer steel in America, the use of railway rails made of this material rapidly increased, with varying degrees of success until the Open-Hearth process of steel making was introduced."

Very little complaint has ever been recorded against the wearing quality of Bessemer steel rails, but rail failures seem to have increased to a great extent, reaching a climax at about the time of the founding of the American Railway Engineering Association in 1900. The reports of the Rail Committee of this Association and the active discussion which followed them, provide an excellent source of information as to the service life and of the failures which have accompanied the use of both Bessemer and Open-Hearth steel rails. That Bessemer steel rails gave satisfactory service life is shown by the following quotations from the Proceedings of the American Railway Engineering Association:

Vol. 1, page 120. P. A. Peterson (Chief Engineer, Canadian Pacific):

"I would like to know why we do not get as good rails as we did in the olden days. We have 56-pound rails in our road that were laid in 1875 of which there have been very few broken, and we run our heaviest engines over them at sixty miles an hour. I would like to hear from Captain Hunt why these rails are better than those we get at the present day, weighing 80 pounds to the yard."

Captain Hunt's reply was to the effect that the earlier-made rails were rolled at lower temperatures and with smaller reductions per pass through the rolls, thus producing better steel.

On page 176 of Vol. 6 of the Proceedings of the American Railway Engineering Association we find, in a discussion of proposed Rail Specifications, a letter written by J. T. Richards, Acting Chairman, American Society Civil Engineers Committee on Rail, in which, among other things, he says:

"Your Committee has also obtained and discussed data pertaining to the service of rails made by different metallurgical processes, and under various specifications. In addition to this they are keeping record of the use by American and other railways of rails of the American Society's sections.

"In the judgment of your Committee, all of this will enable them to later make a more definite report to the Society."

"However, in the meantime, they would report that correspondence with the engineers of the railways of the United States and Canada evidences that while the wear of the heavier sectioned rails is not as satisfactory as that of the lighter ones, at the same time there is not a demand on the part of said railways for a change in any of the American Society's sections."

Vol. 6, page 177—Excerpt from a letter of T. H. Johnson to Chairman Webster.

"As illustrating the second point stated above, I would refer your Committee to the analyses of a number of rails made by John Brown & Co. of England, reported by Captain R. W. Hunt in the Journal of The Franklin Institute for May, 1889.

"As the members of your Committee may not all have access to the publication cited, I enclose a typewritten copy of Captain Hunt's article" . . . .

The essential part of Captain Hunt's article is as follows:

"Rails made by John Brown & Co. of England and put down on American railroads some years ago, have been generally held up as ideal rails, and the American makers for a long time supposed that when these rails did wear out so that they could be analyzed the secret of their good service would be told.

"As an illustration of how little regularity or purity of chemical composition influenced the wear, I call your attention to the analyses of thirteen of John Brown rails all of which had filled years of faithful service and have been selected as bright examples of what good rails should be:

Number	*Carbon*	*Si.*	*Phos.*	*S.*	*Mn.*	*Cu.*
1	0.35	0.08	0.128	0.068	0.742	0.048
2	0.39	0.071	0.156	0.155	0.662	0.32
3	0.36	0.103	0.125	0.060	0.815	Trace
4	0.70	0.306	0.111	0.008	0.681	0.016
5	0.36	0.069	0.153	0.131	0.621	0.043
6	0.44	0.208	0.098	0.059	1.046	None
7	0.45	0.102	0.128	0.105	0.616	0.056
8	0.36	0.087	0.148	0.181	0.625	None
9	0.24	0.068	0.131	0.104	0.645	0.005
10	0.37	0.051	0.096	0.050	0.639	Trace
11	0.32	0.089	0.145	0.077	0.745	Trace
12	0.35	0.069	0.077	0.099	0.945	None
13	0.28	0.032	0.084	0.053	0.312	None

"You will observe that carbon ranged from 0.24 to 0.70, silicon from 0.032 to 0.306; phosphorus from 0.077 to 0.156; sulphur from 0.050 to 0.155; and manganese from 0.312 to 1.046. These rails taken as a whole, were chemically a poor lot, but physically most excellent. As these results are fortified by many others, we are compelled to think that physical peculiarities of their manufacture must account for their superiority . . . ."

Vol. 6, page 179—Hunt (Cont'd)

"We cannot expect satisfactory results unless the steel going into it is properly treated in all stages of the rail's manufacture.

"First—The temperature of the conversion must be controlled.

"Second—The recarburizer must be thoroughly mixed throughout the mass of blown metal.

"Third—Time and opportunity must be allowed for the escape of the confined gases.

"Fourth—Care must be exercised in pouring or casting the ingots, not only in keeping the steel from spluttering against the sides of the ingot molds, but also that the final manner of pouring each ingot shall act as a sinkhead and the gases allowed to escape, so that an excessive length of spongy tops to the ingots shall not be made.

"Fifth—The ingots must not be taken from the perpendicular position until the interior of the steel has had time to solidify.

"Sixth—The steel must not be overheated in the heating furnace, whatever form it may be, either in the shape of ingots or blooms.

"Seventh—All defects should be carefully cut off and out before the steel is put in the finished shape.

"Eighth—The temperature of the metal while receiving the final passes or reductions in the rolls should be low."

Another report of service life of Bessemer steel rails which is of interest is given in Vol. 13 of the A.R.E.A. Proceedings, beginning on page 573. It reads as follows:

"Vol. 13—page 573. A study of seventeen good service rails by Robert Trimble and W. C. Cushing—Table I—carbon ranging from .475 to .641 and phosphorus from .094 to .189—service life from 7 to 17 years.

"Conclusion—This study indicates that the present specifications for Bessemer rails are consistent with long service and that under some conditions a segregated rail high in phosphorus and possibly also carbon, may give long service. Although it does not define these conditions, either of track or of material."

Another case of excellent performance of Bessemer steel rails is found in a letter from Dr. P. H. Dudley to the Rail Committee and published in Vol. 14 of the A.R.E.A. Proceedings, beginning on page 193, in which he said:

"I have delayed answering your letter in reference to the ductility tests under our specifications until we had more experience in reference to the non-failure of the Open-Hearth rails which I designed of large ductility and toughness for the low temperatures of our winter service.

"See Section 1, Chemical Composition, and Section 4, Drop Test and Ductility Tests, of attached specifications.

"The temperatures in the Mohawk Valley on the New York Central have been 20 degrees below zero for several successive days and 40 degrees below for two or three days. Nearly similar temperatures have been experienced on the Lake Shore and Michigan Southern, and 20 degrees below on the Cleveland, Cincinnati, Chicago and St. Louis Railway to date, however, out of our 124,000 tons of basic Open-Hearth rails, commencing with 3000 tons laid in 1908, 4000 tons in 1909, which were made under our former specifications of the elongation measurements for single blow of the drop, and including the first rails rolled under our present specifications, 10,900 tons in 1910 and 106,000 tons in 1911, under the ductility, five 1908 rails failed though none were reported as broken, five rails have broken in the 1909 rails, which were accepted under the elongation of only a single blow of the drop. It was the latter experience which induced me to provide more complete ductility tests for our basic open-hearth rails, resulting in the present specifications.

"To date there has been reported out of 117,000 tons of basic open-hearth steel for 1910 and 1911, five broken rails due to ordinary traffic and four due to bad wheels. This statement is important in consideration of the minimum ductility permissible in our specifications for a few melts of steel.

"It is reported by the Engineers of Maintenance of Way that Bessemer rails in the track either side of open-hearth rails were injured by bad wheels without producing any fractures in the latter under the same wheel loads, rates of speed and in the low temperatures mentioned."

While numerous mentions are made of good wearing quality of Bessemer steel, the only complaint against its wearing quality is confined to a mention of one or two cases of the rail mashing badly, indicating too soft a steel. Where such complaints were followed up by investigations, it was found that the trouble was due to the rolling of the rails at too high temperatures.

A great deal of complaint, however, was raised against the Bessemer steel because of increasingly excessive rail failures. Many complaints were voiced in the conventions of the A.R.E.A. such as the following:

Vol. 6, page 191—

"Mr. Cushing—Since 1899, every year without question, has brought a worse rail than the previous one; all that is necessary is to look at the reports that come in. It has gotten to be a very serious question, and the trouble we have had has been largely from piped rails", etc.

Also from H. R. Safford (Illinois Central):

"Our experience in the last five years with 85-pound rail, which is the section we have used almost entirely, is in the direction outlined. We did not have a great deal of trouble with broken rails until last winter, rails laid two or three years ago. Our trouble has been largely from piped rails and from soft rails in which the wear is evidenced on the curves. Our broken rails in the last year, however, have been mostly on straight track, and contrary to the statement of one of the speakers who said that traffic conditions are much heavier than they were some years ago, I will say that the track conditions were much superior, the line having been ballasted in that time and the wheel load little increased, which shows that we get more brittle rail. We have looked into the chemistry part of the proposition very thoroughly, and do not feel that the trouble is in the chemistry. Our specifications run closely to the specifications of the Association. We have felt that the trouble was largely mechanical, and the question which interested us probably more than anything else is the proportion of the ingot which should be removed."

Also on page 193—F. H. McGuigan (Grand Trunk):

"Notwithstanding the statements of the gentlemen representing the Illinois Steel Company that they are making just as good rails as they ever did, our observation has been that it would not be difficult to disprove their claim. Although we have not used any of their rails for sometime, I do know that the quality of the rails we have purchased has become more inferior each year; also that we had in our track a considerable quantity of rail weighing only 60 pounds per yard, which we considered almost worn out, but which has given better wear than the new rail weighing 80 pounds per yard laid from the end of it.

"In the Province of Quebec, some four years ago, we laid during the last week of October and the first week of November, 5½ miles of new 80-pound rails, and were compelled to take out one hundred and twenty-three of these rails before the following April on account of wear and breakage. Just a few miles further east we had a stretch of 65-pound rail carrying exactly the same tonnage, all of which had been in service over ten years, and not a single one of those rails broke or gave out during the period mentioned. If the gentlemen have confidence in their claim that the new rail is as good as the old, I should like to have them explain why the 60 and 65-pound rails carried the same tonnage, under exactly the same conditions, without a break, while the new 80-pound rail was breaking continually.

"We know further that during the past three years we have been getting the worst rails we have ever used—a considerable portion of it was made by our friends of the Carnegie Company. We purchased some on the other side of the Atlantic—and after these English rails had been in track a little while we concluded that they were worse, if possible, than the Carnegie rails.

"We contracted also for a considerable quantity of German rails, which were delivered about the same time as the English rails, and they were equally as bad" . . . .

Numerous other complaints regarding rail failures in Bessemer steel rails were made, the climax undoubtedly being voiced in the following, quoted from the Proceedings of the American Society for Testing Materials—1908, page 121:

"J. R. Onderdonk—I would just like to say a few words in regard to rails, from the standpoint of the railroad. A few years ago we began to feel that all of the rails were poor, some of them better than others. On the Baltimore and Ohio Railroad the principal trouble with the rail has been the wear and breakage due to slipping of drivers, the split head, and lately the corrugated rail. The split head has given us more concern than any other form of failure. About three years ago the split head question became so serious that, out of 10,000 tons rolled and put in the track, 22 per cent were removed during the first year on account of depressions in the head. When broken apart, the majority of them showed this opening in the head. The percentage of crop from the ingots from which these rails were rolled, varied from 3 to 5. When the head split on the gage side it was liable to cause derailment, and the matter was so serious that it was suggested that 30 per cent would be cropped from the ingot. For several years, that percentage was cut from the top of the ingot. The rails rolled by the same concern, cropping 30 instead of 5 per cent, and placed in the same division, with practically the same traffic over it, reduced the percentage of split heads from 22 to 1¾ during the first year,

although the 30 per cent discard did not begin at the first of the year. The split heads were reduced to about 0.6 per cent for the second year's rolling, showing that the cropping of the ingot prevented, to a large extent, the split heads. The burning of the head of the rail, due to the spinning of drivers, has caused some broken rails, but a rail broken into two or more pieces is a rare occurrence. The burnt rail usually shows a crack extending down into the head, and in some cases as much as three-fourths through the head.

"The moon-shaped breaks spoken of do not occur on this road, unless the track man misses the head of the spike and strikes the flange," etc.

The complaints such as given above brought about an instruction being given to the Rail Committee of the A.R.E.A. to secure data and to prepare, each year, a report on the rail failures occurring on the railways represented by members of the Association, and the first report of the Committee is found to be as follows:

Vol. 11, page 237, "Statistics of Rail Failures."

"The first rail failure statistics for the six months' period from April 30th to October 31st, 1908, have been printed in Bulletin No. 111 on pages 3 to 42, inclusive. The rail failure statistics for the period of six months from October 31st, 1908, to April 30th, 1909, have been printed in Bulletin No. 116 on pages 67 to 155, inclusive, and the circular requesting statistics for the six months' period from April 30th to October 31st, 1909, has just been issued by the Secretary of the American Railway Association," etc.

The rail failure reports have been continued each year from 1911 to the present, and they show a gratifying decrease in the number of failures of rails in proportion to the number in track.

Credit for the decrease in rail failures has quite generally been given to the Open-Hearth process of manufacture, and the change in the chemical composition of the steel, but a thorough review of the conditions raises a very grave doubt as to whether an equal improvement would not have been made, even if the Bessemer steel process and chemistry had been continued, with the improvement in other conditions made as they have been.

For instance, at the time of the founding of the A.R.E.A. the practice in regard to discard from the top of the ingot was a crop of but 4 per cent. In one of the early conventions of the Association, one member advocated adoption of a clause in the proposed "specifications for the manufacture of rails," to require the top discard from the ingot to be increased from the customary 4 per cent to 12 or 15 per cent.

In the statements of Mr. Onderdonk before the American Society for Testing Materials, as quoted above, the 22 per cent of failed rails were from a rolling of rails made in 1905 in which the top discard was from 3 to 5 per cent. This excessive number of failures, practically all of them due to flaws, appears to have been the "last straw," for in the Proceedings of the A.R.E.A., Vol. 7, page 549, the following is reported.

"Piped rails—Frequency of occurrence, cause and recommended remedy.

"We find from reports received that piped rails are frequent in occurrence. We submit the following modification of proposed specifications of the A.S.C.E. on this subject.

"There shall be sheared from the end of the blooms formed from the top of the ingots not less than twenty-five per cent and if, from any cause, the steel does not then appear to be solid, the shearing shall continue until it does. If, by use of any improvements in the process of making ingots, the defect known as piping shall be prevented, the above shearing requirements may be modified."

On page 560 of Vol. 7 the information is given to the effect that the proposal to require a 25 per cent discard was adopted.

In 1907, Vol. 8 of the Proceedings, no report of the Rail Committee is to be found. However, in 1908, Vol. 9, the provision for a 25 per cent discard was nullified by a mo-

tion to allow the discard provision as given in the previously adopted specifications to stand until new specifications should be adopted.

In 1910, Vol. 11, page 254, a new set of specifications for steel rails was offered in which the provision for discard read as follows:

"(4) The end of the bloom formed from the top of the ingot shall be sheared until the entire face shows sound metal."

This provision was adopted as presented, leaving the question of the amount of discard unspecified. It was generally understood, however, that the Rail Committee and the manufacturers had reached a "gentlemen's agreement" to the effect that the discard should approximate 12 per cent of the ingot.

As a consequence of this action, the Open-Hearth steel, which by this time had become the prevailing type of steel used for rails, was relieved of the failures which had previously been occurring in the rails which had been made of the metal between the 4 per cent level and the 12 per cent level of the ingots.

In one of the reports of rail failures, made to present a comparison of the number of failures by position in the ingot, a few years after the increased discard provision had been put into effect, it was shown that more than 50 per cent of the failed rails were "A" rails.

What percentage of the failures in the rails made with a four per cent discard would probably be found in the part of the metal from above the 12 per cent line?

Other features in the manufacture of rails, which make for fewer failures, and which have been adopted since the use of Bessemer steel was abandoned should be cited as follows:

(2) In making drop tests of Bessemer steel rails one (1) test piece from each five heats of steel was tested, if it stood the test all rails of the five heats were accepted but if it failed, the rails of all five heats were not rejected, another test piece was cut from some other of the five heats and if it stood the test, still another piece was cut and tested and if it also passed the test the rails were accepted.

(3) Until 1905 the test specimen for the drop test could be taken from any part of the rail bar made from an ingot, the result being that the test piece was usually selected from what was thought to be the best part of the rail bar.

(4) Until about 1907 or 1908 the test rail was placed on the anvil "head up" or head down as suited the maker.

Other factors which aid in producing less rail failures in the Open-Hearth rails than were occurring in Bessemer steel rails are as follows:

1. The making of bigger ingots, consequently fewer "A" rails.
2. Specifications which provide for keeping ingots in a vertical position until the metal has fully solidified, thus decreasing the depth of pipe.
3. Bigger rails—with increased strength to carry loads.
4. Use of more and better ballast in tracks.
5. Use of tie plates, thus securing more uniform bearing for the rails.
6. Longer rails—increased length of rails means fewer rails containing top metal of the ingot.
7. Until the use of Bessemer steel rails had practically ended, all comparative reports of failed rails, as made by the Rail Committee, showed the number of failures per 10,000 tons of steel.

Inasmuch as the earlier rails, and consequently the Bessemer steel rails, were of lighter weights and shorter lengths the total number of rails in 10,000 tons of steel was considerably greater for the Bessemer steel as it actually existed than was the case for Open-Hearth rails as made.

The actual number of rails in 10,000 tons of steel, by various weights and lengths, are as follows:

60-pound section	30 ft. long	37,333 rails
60-pound section	33 ft. long	33,939 rails
75-pound section	30 ft. long	29,866 rails
75-pound section	33 ft. long	27,151 rails
85-pound section	33 ft. long	23,957 rails
90-pound section	33 ft. long	22,626 rails
90-pound section	39 ft. long	19,145 rails
100-pound section	33 ft. long	20,363 rails
100-pound section	39 ft. long	17,230 rails
110-pound section	39 ft. long	15,664 rails
130-pound section	39 ft. long	13,254 rails

8. Prior to about 1910 or 1912 it was the practice to leave defective rails in track much longer than at present, in fact, it was not uncommon in the earlier years to leave a mashed or split rail in track until it broke, thus accounting for many rails reported broken that in present times would be renewed as soon as they were known to be defective and reported as piped or split head.

9. Better maintenance in later years should also prevent some of the rail failures of earlier times.

10. A final factor which must not be overlooked, and one which was responsible for many of the actual broken rails in Bessemer steel rails was the use of the thin base rail sections prior to the adoption of the A.R.A. and A.R.E.A. thick base sections.

Regarding the performance of Bessemer steel rails, C. B. Dudley, Chemist for the Pennsylvania Railroad, when making his President's address to the American Society for Testing Materials in 1908, had this to say:

Page 28—Proceedings A.S.T.M. 1908:

"Insofar as the more rapid working of the Bessemer process, which has seemed to characterize its full commercial development during the past twenty years or more, has led to incomplete action between the final additions and the blown metal, and to higher finishing temperatures in the finished rail, the metal must be inferior. The making of steel is a chemical process and every chemist knows that all chemical reactions require time, and it is to be feared that Bessemer metal is, many times, cast in the ingot mold, before the reactions are complete," etc.

Page 33, C. B. Dudley (Cont'd.)

"And this brings us to the question of tests and testing. During the past few years, much light has been thrown on the subject and the truth compels us to say that a situation has been found that, in some respects, would be ludicrous if it were not so near the tragic. Let us see what the conditions have been:

"1. The manufacturers have, in many cases at least, selected the rail end as sample for test. The specifications being silent on the selection of the test piece, they naturally have urged that there was nothing to prevent their doing this, and they naturally again have, so far as information can be obtained, chosen the best steel of the ingot for test, etc.

"2. The best two in three principle has pervaded many specifications, that is to say, if the first rail end stood the test, the heat was accepted, but if it failed, a second was tested, if this likewise failed, the heat was condemned. If on the other hand, it stood the test, a third was tested, and the fate of the heat was decided by the majority. It would almost seem as though the specification had been drawn, not with the idea of being sure that only good rails should be accepted, but with the idea of being sure that as many heats as possible should be accepted.

"3. Only one heat in five was tested, that is to say, if the (one) rail end stood the test and the heat was accepted, that acceptance carried four other heats with it. But singularly enough, on the other hand, if the heat was rejected, that rejection covered only the heat from which the test rail end came, and the four preceding or following heats,

as the case might be, got another chance for their lives. The unsatisfactoriness of such a method must be evident to every candid mind that knows anything about the making of steel . . . .

"We fancy the rather loose testing, described in the three items above, started in the earlier days, when the strain on the rail was far less than at present, and the traffic far less dense, and has been perpetuated, partly owing to inertia on the part of railroad engineers, and partly owing to the resistance of rail manufacturers. The wonder is, with such loose methods of testing as has been in vogue, not that there have been so many rail failures, but that there have not been more."

Further, the drop testing machines were of any pattern which the mill cared to furnish. Some of them having the anvil supports very close together, one mill even using two old ingots laid in contact making virtually uniform and continuous support for the test piece.

The A.S.T.M. Rail Committee at a meeting on April 27th, 1908, adopted the following:

"First—That many of the drop testing machines used in the past have given very fallacious results, owing to inferior foundations and anvils."

When the new types of failures which have appeared with the use of Open-Hearth rails are taken into account, it is doubtful that the Open-Hearth steel rails are giving as good an accounting of themselves as the rails made to Bessemer chemistry would have done had that process been given all of the aids which have come to the rescue of the O.H. rail.

The types of failures which are now quite prevalent and which were rarely or never found in Bessemer steel rails are:

1. The horizontal split head—by the Rail Committee called the horizontal fissure.
2. The head check, or detail fracture.
3. The transverse fissure.

In making a study of these kinds of failures, in addition to the older forms, it will be necessary to study the factors and features of steel making. The first feature taken up will, therefore, be the matter of segregation of material in the ingot of steel from which the rails are made.

Beginning on page 655 of Vol. 13 of the Proceedings of the American Railway Engineering Association, is found a very valuable study of the segregation of the elements which enter into steel making.

In that study, full sized ingots of Bessemer rail steel were split open and studies made of them. Fifteen rows of holes were drilled across the ingot and chemical analyses were made from the drill chips from each hole.

See Fig. 8, page 665 and Fig. 9, page 666, Vol. 13.

On the pages that followed were given the tabulated results of the analyses.

In the Committee's review of the tests, attention is called to the fact that practically all of the segregation of both carbon and phosphorus is confined to the top 25 per cent of the ingot, but no further study as to the actual amounts of segregation was mentioned.

On page 675 the tables showing the analyses of carbon and of phosphorus, for a 20 by 24 inch ingot are given. As this was a normal size ingot which seems to be of typical analysis, a further study is made of it as follows:

Average carbon content of the entire ingot amounts to .547 per cent which represents 12.25 pounds of carbon in each ton of steel. The maximum amount of carbon found was .85 per cent which represents 19.04 pounds of carbon in each ton of steel. The total amount of segregated carbon, therefore, lies somewhere between these two

The average phosphorus found in the entire ingot amounts to .092 per cent, which represents 2.06 pounds of phosphorus per ton of metal.

The maximum amount of phosphorus found amounts to .199 per cent, which represents 4.45 pounds of phosphorus per ton of metal. Again the total amount of segregated phosphorus lies somewhere between these figures.

In the making of Open-Hearth steel rails the present A.R.E.A. specifications provide, in the case of 110-pound rail:

Carbon from .67 to .83 per cent—average .75 per cent.

Phosphorus not over .04 per cent.

On the average of the above figures, the carbon content would amount to 16.8 pounds per ton of metal. The segregation is usually found to increase with the increase of total amount of the element present, but in this case it is assumed that the segregation remains the same as given above, or .303 per cent higher than the average. The maximum carbon would then be represented by 1.153 per cent which would indicate 25.83 pounds of carbon per ton. A difference of 9.03 pounds of carbon, and the actual segregation is somewhere between zero and this 9.03 pounds. If the phosphorus be taken at the full .04 per cent it represents but 0.896 pounds per ton of metal, and since the total difference between average phosphorus and the maximum segregation figure for phosphorus in the Bessemer steel was but 2.39 pounds per ton, the actual amount of segregated carbon will have to be much smaller than is usually found to show a decrease in total segregated material in the high carbon Open-Hearth steel from that usually present in the Bessemer steel.

The next factor in steel making to be taken up is the matter of working temperature. Kent's Engineer's Hand Book shows the welding temperatures of iron and steel to be from 2250 to 2350 degrees Fahr. upward, while the rolling temperature of steel ranges from 2070 to 2100 degrees downward, for the ingot upon entering the first pass through the rolls.

This difference between welding and rolling temperatures has a very important bearing upon the prevalence of horizontal split heads in present-day rails.

The following quotation from Stoughton's Metallurgy of Iron and Steel, second edition, page 271, throws some light upon this matter:

"For this reason the Bessemer and the acid Open-Hearth steel making processes are more expensive for casting work than the basic Open-Hearth. The result is a present rapid increase in the use of basic Open-Hearth steel in America, as well as in Germany, with a probability that in a few years it will be the predominate process for this pur-

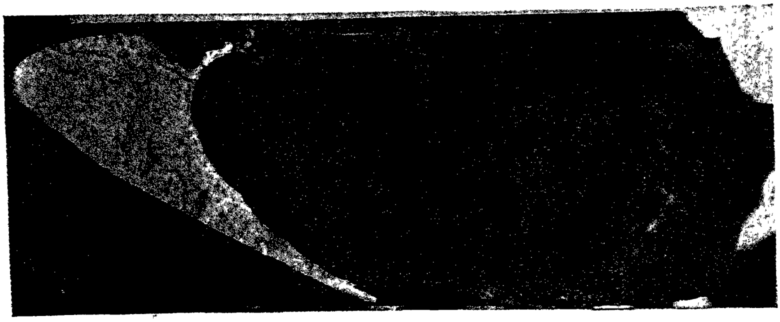


FIG. 1—Showing Horizontal Fissure—Looking Down on Top of Head.

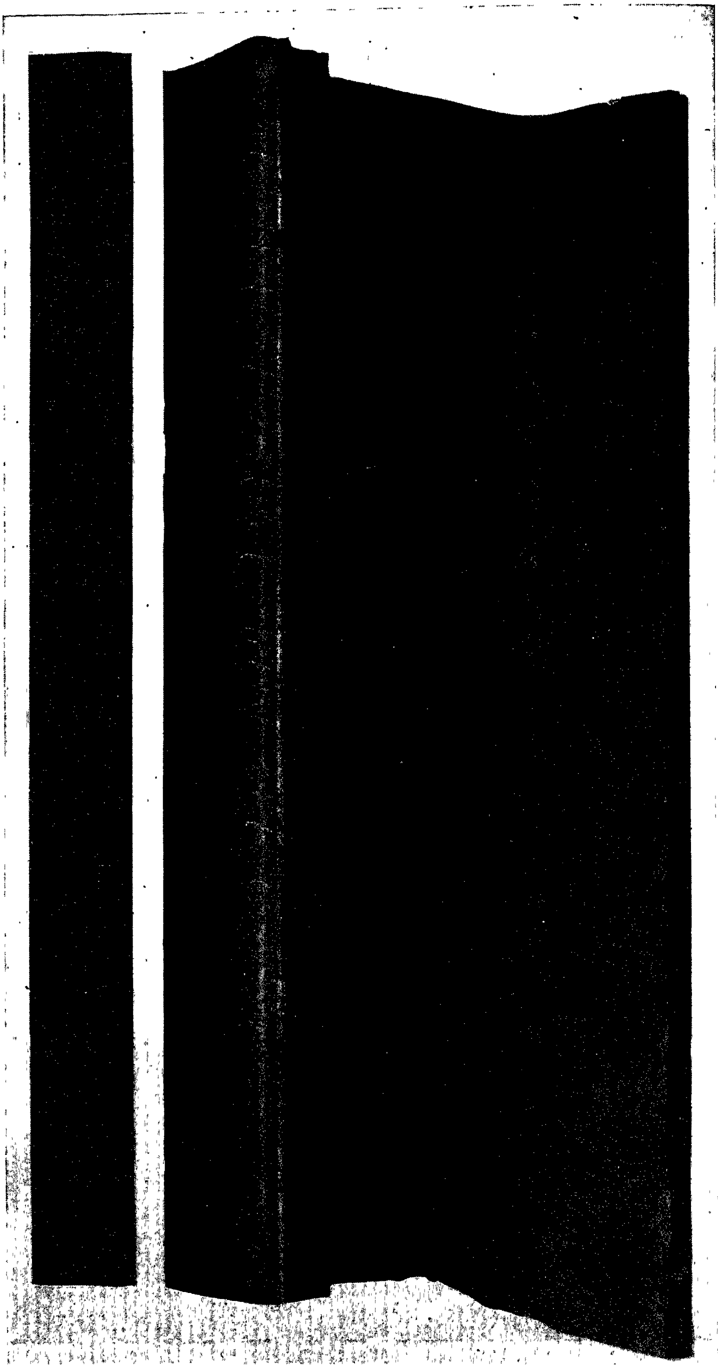


FIG. 2—Head Check Rail—Side View.

pose. This is in spite of the fact that basic steel has very serious disadvantages, chief among which are the amount of oxygen contained in it at the end of the process and the difficulty of keeping the desired amount of silicon in it during teeming, both of which conditions increase the liability to blow holes, which are especially objectionable in castings, as there is no opportunity of their being welded up," etc.

Since the rolling of rail steel takes place at a temperature below a welding heat there is no opportunity for the welding up of blow holes or gas bubble cavities in the manufacture of rails. The result is that in most cases the gas is forced out of the steel in the process of rolling and the sides of the cavities are flattened together but not welded, therefore a seam is left in the steel and if in the head of the rail it frequently causes a failure by the horizontal split of the type frequently called a horizontal fissure. An examination of such failures will in most cases reveal a comparatively smooth surface, with no indication of grain or broken metal.

The head check failure, or detailed fracture as sometimes called, shows a smooth surface, usually almost a quarter circle, with the center seemingly about where the planes of the side, and of the top, of the rail head, would intersect if extended. This quarter circle has the smooth surface of the transverse fissure failure outside of the rough spot nucleus of a fissure. The head check failure develops in Open-Hearth rails which have been subjected to the tractive force of locomotive drive wheels when under heavy pulling forces. The effect of this pull of the drivers is to distort the metal along the gage edge of the rail head, causing it to separate into thin sections, much as though the rail were composed of transverse laminated sheets. After the distortion has opened the older type is the transverse fissure which develops around a small cavity running a slight surface crack, the fracture develops with the same smooth surface of the transverse fissure. No such failures have ever been reported in Bessemer steel, and obviously because the manganese and phosphorus content of the steel produced a metal that was tough enough and hard enough to resist distortion by the engine drivers.

Fig. 3—Head Check—End View.

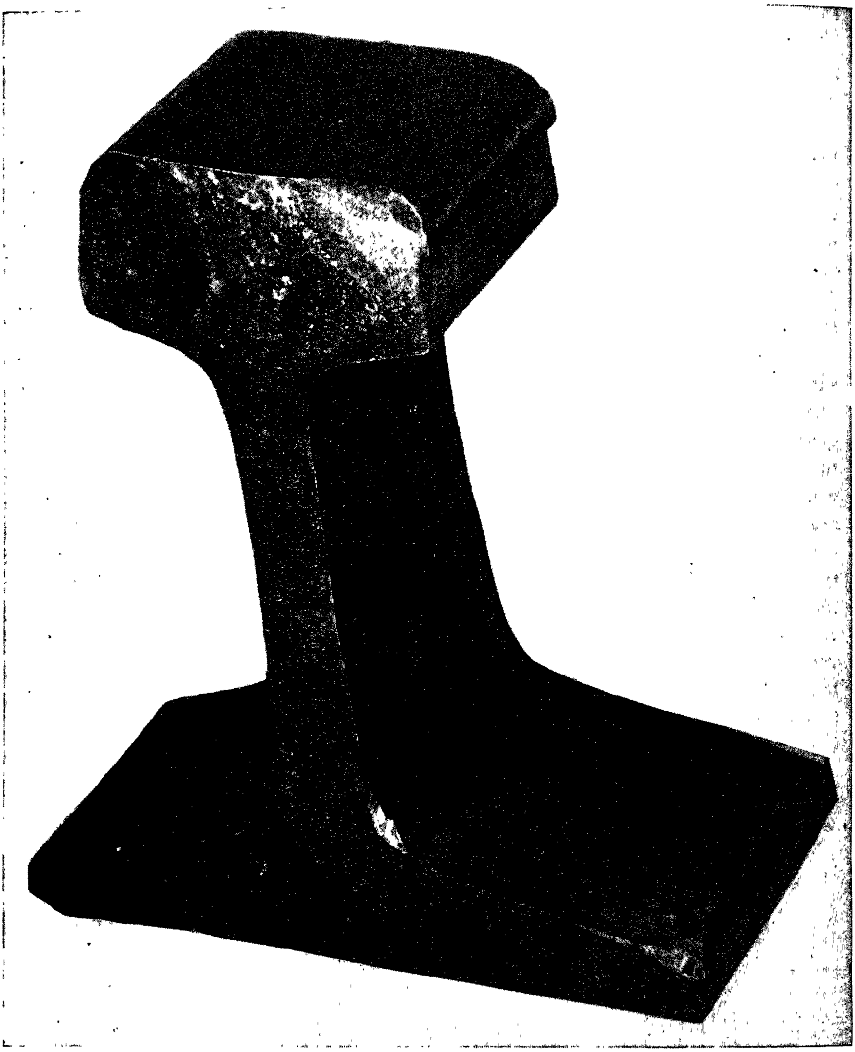


FIG. 4—Head Check Rail—End View.

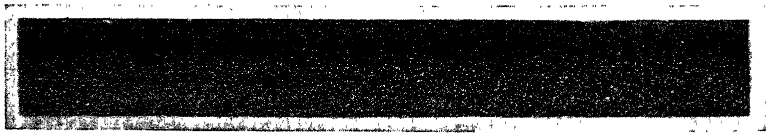


FIG. 5—Edge Section Showing Head Checks Only.

The transverse fissures:

While the transverse fissure in general is quite well known, the search for its cause has been delayed or made more difficult by the failure of many persons to make a sufficiently close study of the different types of failures variously classed as transverse fissures.

Two distinct types should be easy to distinguish. The first, because undoubtedly the older type is the transverse fissure which develops around a small cavity running lengthwise through the rail, or around some small defective spot. All transverse fissures so far known of by the writer, including those pictured in the Proceedings of the A.R.E.A., to have occurred in Bessemer steel rails are of this type.

FIG. 6—Specimen L-366-B. 5⅛-inch 80-lb. section. L. I. & S. Co., South Works. Bessemer steel. Heat No. 3718. Rail letter—unknown. Rolled 1901. Failed May 14, 1914. Nucleus of the interior transverse fissure. Cavities.

FIG. 7—Specimen L-451-C. 6-inch 100-lb. section. L. I. & S. Co., South Works. Bessemer steel. Heat No. 26011 "C" rail. Rolled July, 1897. Failed May 4, 1914. Nucleus of the interior transverse fissure. Cavities.

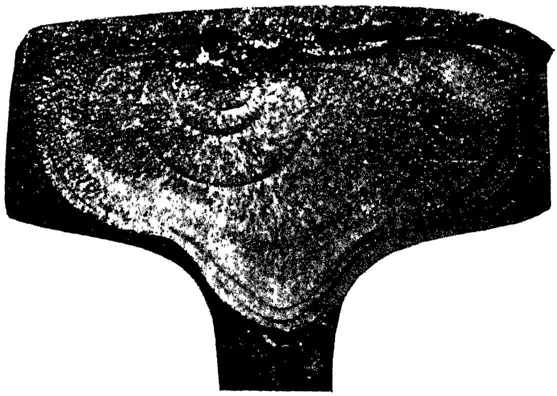


FIG. 8—Specimen L-496-C. 6-inch 100-lb. rail head. L. I. & S. Co., South Works. Bessemer steel. Heat No. 68188 "C" rail. Rolled July, 1897. Failed May 10, 1915. Nucleus of the interior transverse fissure. Cavities.

FIG. 9—Specimen L-488-D. 5⅛-inch 80-lb. rail head. L. I. & S. Co., South Works. Bessemer steel. Heat No. 359090 "B" rail. Rolled February, 1901. Failed March 3, 1915. Nucleus of the interior transverse fissure. Cavities.

The transverse fissure which develops around the rough spot nucleus might well be termed the true transverse fissure. Many failures that are classed by some as transverse fissures, and by others as compound fractures, show a half circle, or more, of smooth silvery spot which has developed from a seam or some other flaw in the steel, giving what appears to be a part of a transverse fissure but lacking in the rough spot nucleus.

It is the fissure which develops from the rough spot nucleus which is of the most concern.

Fig. 10.

The fissure shown on Fig. 11, below, is of the rough spot nucleus type, while fissure No. 12 appears to be a development around a flaw or cavity, the position of No. 12 being in the center of the rail head also indicates that a flaw served as a nucleus. Fig. No. 10 shows the half smooth spot developed below a seam which extended crosswise through the rail head.

Fig. 11.

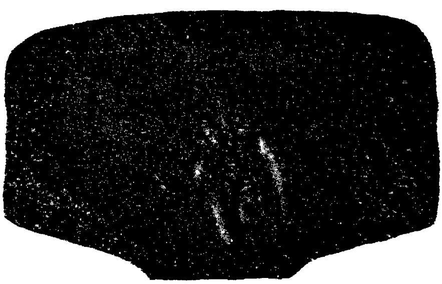


Fig. 12.

The cause of transverse fissures, of all types except that having the rough spot nucleus, is fairly easy to define and the method of development of the transverse fissures having a rough spot nucleus seems to be pretty well understood, but the underlying cause for the initial rupture of the rough spot area has not as yet been fully explained.

Beginning on page 1022 of Vol. 13 of the Proceedings of the A.R.E.A. there is a discussion of the rail situation by J. E. Howard, a part of which reads as follows:

In discussion of Proposed A.R.E.A. Rail Specifications.

"In regard to the 4th paragraph—Higher carbon steel rather than a mild one is certainly necessary, but there is danger in going too far, getting too high a carbon, introducing great brittleness, therefore I am inclined to favor a medium carbon; doubtless the zone of safety lies around 0.65 per cent to 0.70 per cent, or a little outside those limits."

Question. The President—"For Open-Hearth, Mr. Howard?"

Answer. Mr. Howard—"I am not prepared to make a distinction between the two kinds of steel at the present time.

"The feature of ductility is one to be considered and we do know this—that when a material is subjected to repeated alternate stresses it may be ruptured without the display of any ductility whatever. If we have a very low carbon steel, although one of great ductility at the outset, when this is subjected to a comparatively low fiber stress, in alternate directions, we very quickly reach a brittle fracture. That metal will fail without any display of ductility, and the hardest steel can hardly do less. It is necessary to start with considerable stiffness or strength in the material to resist bending stresses. The ductility which you find in the drop test is inherent to the new material and not to that which has been repeatedly strained. It is not necessary that the over straining force reaches the elastic limit of the material, to bring about that final state of brittleness. Too soft a matal is undesirable to use. If the metal is a strong one, a higher stress can be endured repeatedly without impairing the final ductility or such ductility as the metal may incidentally be called upon to develop. That leads me to the use of rather high carbons and to be conservative, I think 0.55 to 0.70 is a fair limit.

"The dangers of high carbon, as I see them, are somewhat along these lines. With high carbon steel and high wheel pressures, we reach an unsatisfactory internal condition. To follow the action of the high wheel pressures, they move the metal on the surface of the head and induce internal strains of compression. These internal strains may be of considerable magnitude, and when they exist there must be a tensile component in the steel below it. In that case we have below the running surface of the head, metal which is put into tension, and if structurally unsound there is an opportunity present for an incipient fracture to develop.

"To show that the stresses from a disturbing cause like those under consideration are considerable, I would mention an example. Referring to a steel forging, one which had walls 3½ inches in thickness. The metal of that cylinder was so disturbed by hammering with a hand hammer, that the bore was measurably enlarged. The dimensions of this cylinder were 8 inches bore 15 inches outside diameter. Hammering the outside surface of the cylinder, the bore was enlarged nearly one thousandth of an inch. Turning off one eighth of an inch of metal on a side restored the diameter of the bore to its primitive dimension. That showed that the internal strains in a zone only one-eighth inch thick were capable of stretching the balance of 3½ inches and making its effect measurable. It meant several thousand pounds stress per square inch to do that, so that it is possible that the cold rolled surface of the head of the rail may have in it internal strains amounting to a number of thousand pounds per square inch, and that coupled with the fact that we may have a decarbonized exterior, with a hard center, the decarbonized exterior responding easily to the rolling of the wheels, the hard interior, through its natural lack of ductility, not responding so well, we have presented ample opportunity, it would seem, for starting a fracture in the hard steel.

"These are features which are regarded as important in considering what the composition of the steel should be and would lead to limiting it to the range in carbon which I have mentioned, and to the exercising of care to see that the steel in the finished rail is fairly uniform in its composition from the exterior surface to the center of the head."

It is interesting to note that the statement made by Mr. Howard as given above was made in the A.R.E.A. convention in March, 1912, and that the first transverse fissure

failure of a rail, which attracted attention, was the one which caused the wreck of a train on the Lehigh Valley Railroad on August 25, 1911.

Again at the A.R.E.A. convention of March, 1919, see Vol. 20, page 886 of the Proceedings, Mr. Howard in discussing the report of the Rail Committee, in which the subject of shatter cracks had been mentioned, said:

"The term 'Transverse Fissure' was applied to a type of fracture which made its appearance in a rail that caused a disastrous wreck on the Lehigh Valley Railroad in the year 1911.

"The fracture started in the head of the rail. It was progressive in its character, the result evidently of repeated stresses in the track, and was therefore, by definition, a fatigue fracture. The peculiarity of the fracture consisted in its having an interior origin, the nucleus of which was located in the gage side of the head. Its interior origin was explainable by reason of the presence of cold rolling strains introduced into the head of the rail by the action of the wheel pressures. Internal strains of compression are imparted to the metal immediately below the running surface of the head, while the metal next below is put into a state of tension.

"The nucleus of a transverse fissure is located in a zone of metal which the wheel pressures have put into a state of longitudinal tension. Under the influence of repeated stresses the transverse fissure extends and may separate the greater part of the head before the final fracture of the rail occurs. No common structural nor chemical reason has, up to the present time, been identified as the cause of the incipient rupture," etc. . . . .

In 1916 a study was made on the Atchison, Topeka and Santa Fe Railway, to determine if possible, what effect the larger engines then in use had upon track and rails. In the course of that study contours were taken of rails of various ages in track.

Copies of such contours are shown in Fig. 13, 14 and 15, and they are of great interest inasmuch as they show that 90-pound section Open-Hearth rails which had been in service not over fifteen months show almost as much apparent wear as did similar rails of the same section, in the adjoining track, which had been in service six years, and in sections marked Nos. 13 and 14 had handled a somewhat heavier traffic per annum than had the newer rails.

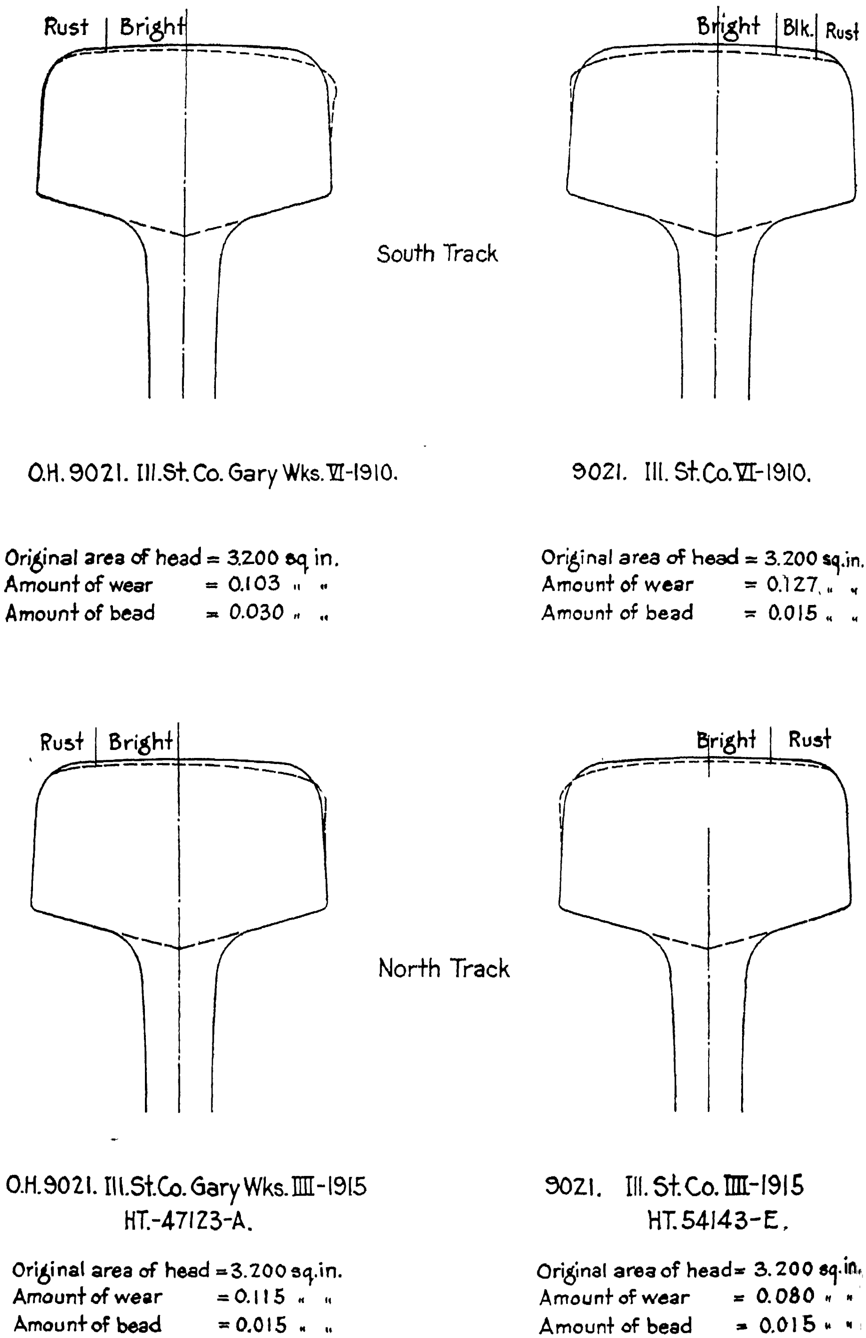
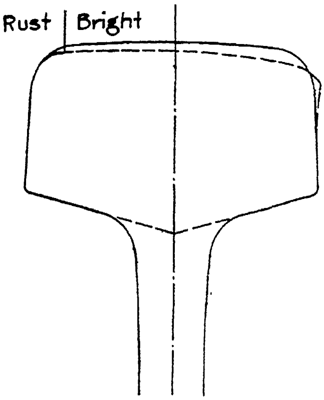

Rust | Bright
Bright | Blk. | Rust
South Track
O.H. 9021. Ill. St. Co. Gary Wks. VI-1910.
9021. Ill. St. Co. VI-1910.
Original area of head = 3.200 sq. in.
Amount of wear = 0.103 " "
Amount of bead = 0.030 " "
Original area of head = 3.200 sq. in.
Amount of wear = 0.127 " "
Amount of bead = 0.015 " "
Rust | Bright
Bright | Rust
North Track
O.H. 9021. Ill. St. Co. Gary Wks. IIII-1915
HT.-47123-A.
9021. Ill. St. Co. IIII-1915
HT. 54143-E.
Original area of head = 3.200 sq. in.
Amount of wear = 0.115 " "
Amount of bead = 0.015 " "
Original area of head = 3.200 sq. in.
Amount of wear = 0.080 " "
Amount of bead = 0.015 " "

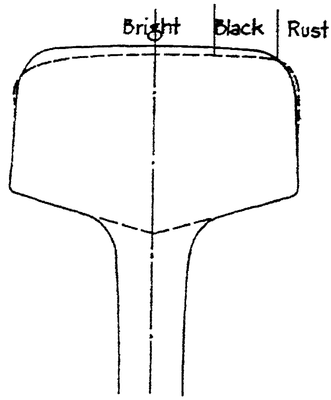
FIG. 13.



9021. Ill. St. Co. VI-1910
HT. 34158-G.

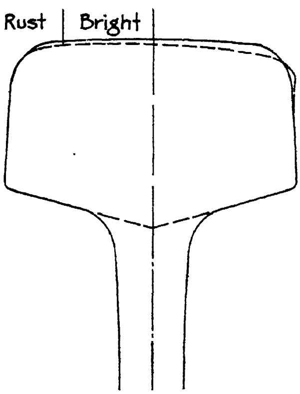
Original area of head = 3.20 sq. in.
Amount of wear = 0.147 " "
Amount of bead = 0.02 " "

South Track



9021. Ill. St. Co. V-1910
HT. 351-X

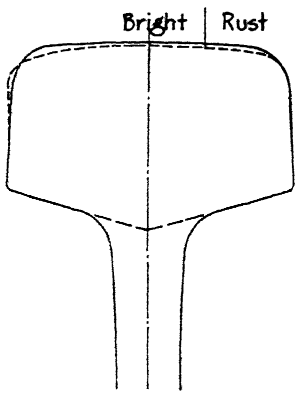
Original area of head = 3.20 sq. in.
Amount of wear = 0.157 " "
Amount of bead, inside = 0.010 " "
Amount of bead, outside = 0.027 " "



9021. Ill. St. Co. IIII-1915.
HT. 51130-D.

Original area of head = 3.20 sq. in.
Amount of wear = 0.103 " "
Amount of bead = 0.010 " "

North Track



9021. Ill. St. Co. IIII-1915
HT. 54143-E.

Original area of head = 3.200 sq. in.
Amount of wear = 0.080 " "
Amount of bead = 0.020 " "

FIG. 14.

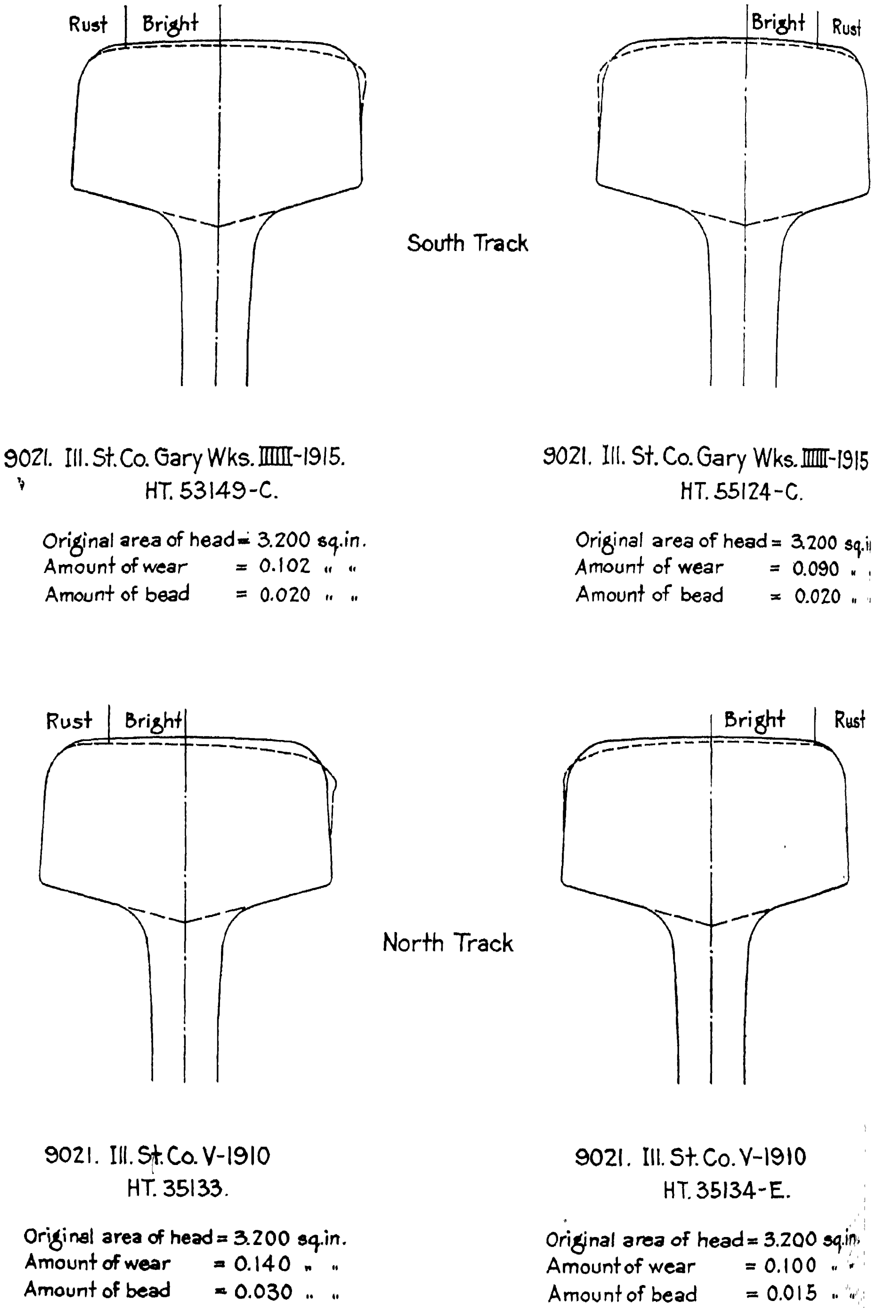

Rust
Bright
Bright
Rust
South Track
9021. Ill. St. Co. Gary Wks. IIIIII-1915.
HT. 53149-C.
Original area of head = 3.200 sq. in.
Amount of wear = 0.102 " "
Amount of bead = 0.020 " "
9021. Ill. St. Co. Gary Wks. IIIIII-1915
HT. 55124-C.
Original area of head = 3.200 sq. in.
Amount of wear = 0.090 " "
Amount of bead = 0.020 " "
Rust
Bright
Bright
Rust
North Track
9021. Ill. St. Co. V-1910
HT. 35133.
Original area of head = 3.200 sq. in.
Amount of wear = 0.140 " "
Amount of bead = 0.030 " "
9021. Ill. St. Co. V-1910
HT. 35134-E.
Original area of head = 3.200 sq. in.
Amount of wear = 0.100 " "
Amount of bead = 0.015 " "

FIG. 15.

From the conditions shown and the known fact that such rails show much harder and denser metal in the running face than existed in them before being placed in service, it becomes evident that the decrease in the height of the rails is not due to abrasive wear but is due to the steel being compressed into itself. That such is the case is confirmed by the experiment made at Sparrows Point, Md., by the Rail Committee of the A.R.E.A. and reported in Vol. 19 of the Proceedings, beginning on page 499. That test not only proved the very considerable compression of the face of the Open-Hearth rail, but also showed that the major part of the compression takes place early in the service of the rail.

These features of the performance of Open-Hearth rails of high ductility show that, so far as he went, Mr. Howard was on the right trail in the search for the cause of transverse fissure failures in Open-Hearth rails. However, if the internal stresses set up within the rail head by the compression of the face metal were the sole cause of transverse fissure failures, then all rails compressed in the same manner should fail in the same way. Since only an occasional rail of the many so compressed fail, it is necessary, in order to find the full cause or causes for such failures, to look for some other condition which when occurring along with the compression strains, will produce a transverse fissure in the steel.

Fig. 16—Transverse Section of Piece No. 3, Etched and Repolished with Tripoli.

In his report No. 42, published in Vol. 16, page 195 of the A.R.E.A. Proceedings, M. H. Wickhorst called attention to what has become known as shatter cracks in steel rails which had failed by transverse fissure. Investigation of these microscopic cracks has been continued by various students of the subject, until it has been almost proven that they are to be found in all rails which fail from transverse fissures of the rough spot nucleus type. In many cases, however, the cracks are so minute that even powerful magnification will not disclose them until after etching with some acid or other reagent has been resorted to.

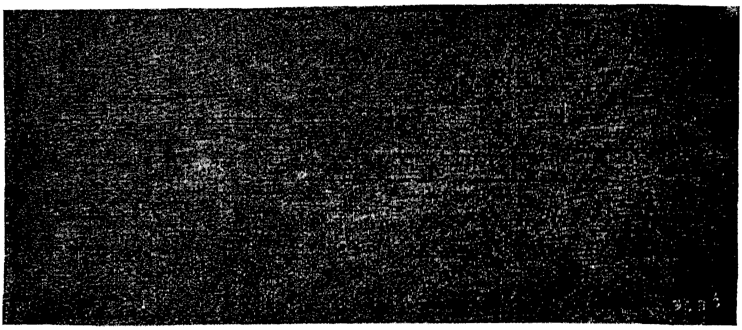


FIG. 17—Etched Horizontal Section at End of Rail 9086.

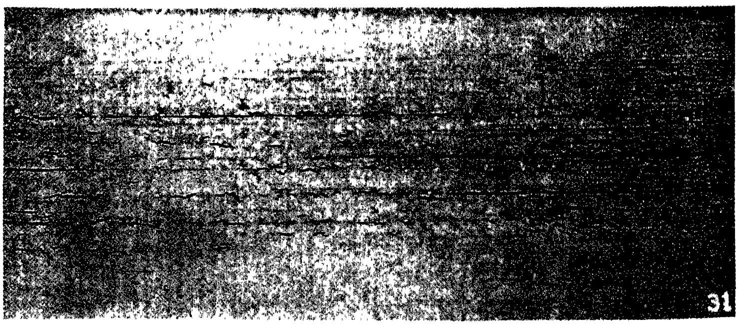


FIG. 18—Etched Longitudinal Section Through Interior of Head of E Rail 31.

Some question still remained as to whether or not the action of the etching reagent might not be forming cracks which did not previously exist in the steel. It remained, therefore, for Dr. C. W. Burrows, of the U.S. Bureau of Standards, to devise a magnetic method of proving the existence of the shatter cracks in the steel before any etching was done. This test is described, beginning on page 1241, in Vol. 21 of the A.R.E.A. Proceedings.

Having established the fact of the presence of shatter cracks in all transverse fissured steel, so far as is known, the next step is to determine if possible the why of these cracks, and to seek for means of avoiding them.

The records that have been kept and the reports and tabulations that have been made of transverse fissure failed rails show the type of failure to be more prevalent in high carbon steel than in the lower carbon steel, and in fact the development of a transverse fissure of the rough spot nucleus type in a rail made of Bessemer steel is, so far, unproven.

The natural line of research, therefore, lies in the actions and effects of carbon in the making of steel. For this reason the following table covering the ingredients more or less prevalent in rail steel is made up:

Element	*Atomic Weight*	*Specific Gravity*	*Melting Point F*	*Boiling Point F*	*Weld. Temp. F*	*Roll. Temp. F*	*Coefficient of Expansion*
Iron	55.84	7.9	2786	4442	2300	2070	.00000673
Carbon	12.00	1.9	6332				.00001154 Down
Graphite		2.3 1.83					
Phosphorus	31.04	2.20 1.93	111.6	550.4			.00006961
Sulphur	32.06	2.07	224.2	832.			.00006556
Manganese	54.93	8.0	2246	3452			
Silicon	28.3	2.39	2588				.00000424
Nickel	58.	8.90	2646				
Aluminum	27.1	2.61	1217	3272			.00001233
Titanium	48.1	3.54	3260				
Copper	63.7	8.85	1981	5050			.00000926

Variations of Iron

Wrought Iron		7.70	2900				.00000633
Cast Iron—3% carbon			2350				.00000589
Steel—.58% carbon							.000006389
Steel—1.00% carbon		7.9	2550				.00000617

It is interesting to note that the melting temperature of pure iron is 2786 degrees Fahr. while that of carbon is 6332 degrees Fahr. or slightly more than two and one-fourth times the temperature required to melt pure iron. Not only is the melting point of carbon very high, but the fact that the first successful electric light was made by burning metallic carbon in the electric arc and that without the slightest melting of the carbon, shows that carbon practically cannot be melted in the open air. This high melting point of carbon makes it quite evident that the carbon in the recarbonizing material which is added to the iron to make steel of it, is not melted in the process. On the contrary it becomes evident that carbon is soluable in liquid iron very much the same as common salt is soluable in water. As salt reduces the freezing point (or melting point) of water from plus 32 degrees to zero so the addition of 1.0 per cent of carbon to pure iron reduces its melting point from 2786 degrees to 2550 degrees.

The early processes of making steel, which consisted of building alternate layers of charcoal and wrought iron bars into a kiln and firing the stack so prepared, allowing it to smoulder for several days, then removing the bars as a well carbonized steel, without either the iron or the carbon having reached a molten state, shows the solvent and the absorbent powers of iron over carbon.

Apparently, as is the case with salt and water, the larger amount of carbon added to the liquid iron the longer is the time required for it to be completely dissolved and assimilated, and seemingly in some cases of steel making, more or less of the carbon particles remain unassimilated in the mass.

Turning now to table of elements in steel, we find that any carbon remaining uncombined in the mass, will be solidified unless the temperature be above 6332 degrees, a temperature probably never used or reached in steel making. The steel surrounding these particles of carbon will become solidified as soon as the temperature falls below 2550 degrees. Manganese will become solidified when the mass temperature reaches 2246

degrees and the remaining ingredients likewise will solidify as their melting point temperatures are passed in the downward trend.

Another factor which must now be considered is the contraction of the steel and such unassimilated particles as may be in it.

The coefficient of expansion of rail steel is generally given as .0000065 while the coefficient of expansion, which also means of contraction, for carbon is listed as .00001154 for common forms of carbon, and downward, with no certain figures for metallic carbon available. With the figures given being 1.8 times as much as the figures of iron, and the fact as given in the Rail Committee's report for 1915, Vol. 16, page 163, that the shrinkage of the hot rail after sawing increased an average amount of .013 inch for an increase of carbon of .01 per cent in the standard length of 33 feet, it becomes evident that the shrinkage of carbon is greater than the shrinkage of iron or steel.

It, therefore, seems logical that the larger the amount of carbon there is in the steel, and the later, in the process of steel making, it is introduced into the mass, the more unassimilated particles of carbon there will be and the more liklihood of the shrinkage of such particles being the cause of the shatter cracks which combined with the stresses set up in the head of the rail by its compression under the wheels, seems to be the combination of conditions which bring about the rough spot nucleus of transverse fissure failures.

Having reviewed the performance of, and failures which occur in railway rails, it is appropriate that some attention be given to the factors which are desirable in railway rail steel.

Railway rail steel should have, first—strength to carry the loads; second—be hard enough to prevent undue compression of the contact face; third—be tough enough to resist wear; fourth—be sound, to prevent failure producing flaws.

In order to learn something of the effects on the strength of steel, of the changes in its chemistry, made since the adoption of the Open-Hearth process of steel making, it is worth while to review the information given under the title, "The Strength of Steel," by Bradley Stoughton, on pages 307 to 310 of his Metallurgy of Iron and Steel. He states that beginning with a carbon content of .50 per cent, the strength of basic Open-Hearth steel is increased 820 pounds per square inch for each .01 per cent of increase of carbon up to .90 per cent. That the strength of the steel is increased 1000 pounds per square inch for each .01 per cent of phosphorus added up to .12 per cent, also that the strength of the steel is increased by 400 pounds per square inch for each .01 per cent of manganese added up to 2.00 per cent.

It is, therefore, evident that a return to the chemistry of Bessemer steel of bygone years with figures as follows:

Carbon	.50
Manganese	1.40
Phosphorus	.12

the strength of steel as compared with the A.R.E.A. present specifications, will be as follows:

Element	*Bess. Chem.*	*Pres. Chem. Difference*	*Resulting Strengthening*
Carbon	.50	Aver. .80 -- 30 x 820 =	—24600 lb.
Manganese	1.40	Aver. .95 -- 45 x 400 =	+18000 lb.
Phos.	.12	Max. .04 -- 08 x 1000 +	+ 8000 lb.
Net change in strength			+ 1400 lb.

It is thus possible to produce a stronger rail by this change back to Bessemer chemistry. In addition the manganese will make a much tougher rail and the phosphorus will make a harder rail, and the decrease in carbon will aid in reducing the transverse fissure failures.

The increased hardness will lessen if not entirely prevent the head check type of failures and the increased toughness should increase the rail's resistance to wear, and the combined increase of toughness and hardness should greatly reduce the number chipped and battered rail ends.

Steel made to the present specifications may have the proper strength and ductility for use as bridge or structural steel, where the tension or compression stress is practically uniform throughout the piece, yet be far from what is needed for rails which must provide strength and elasticity and also take care of the rolling load, and the condensing and wearing effect of such treatment.

Rail steel needs to be hard enough and tough enough to resist the compression of its surface caused by the cold rolling of the wheels to as great an extent as necessary strength and elasticity will permit.

Hardness of rail steel is generally objected to on the theory that hard rails will not be able to withstand the hammer blows delivered upon them, but it should be remembered that there are no blows or loads imposed upon the rails except by the wheels passing over them and the wheel loads are rolling loads with no hammer effect except when a low rail end causes a drop of the wheel or where a high rail end or other high spot causes a bounce of a wheel with a consequent blow on the return of the wheel to contact with the rail. It should further be considered that the force acting on the rail is to an equal extent reacting upon the wheel which produces it, and a large percentage of the wheels which are operated over a railway rail are made of cast iron, a material which at best is far weaker and far more brittle than is rail steel. Not only are many of the car wheels made of cast iron, but they are made with chilled tread surface. Of this subject Stoughton's Metallurgy of Iron and Steel has the following to say:

Page 318.

"American railroad car wheels which are cast against an iron chill give nearly an inch depth of white iron around the tread and flange where the metal is to suffer abrasion in grinding over the rails."

Page 316—white cast iron—

"It is so brittle as to be readily broken by the blows of a hammer and is weak because of the presence of very large plates of cementile."

It is these same chilled cast iron car wheels which must deliver the majority of the stresses which the rails must endure, and very few cast iron car wheels fail except where some flaw or defect is the cause, and likewise very few rails of either earlier Bessemer steel or present day Open-Hearth steel did or do break without some flaw or other unusual condition being the cause.

As to piped rails and flaws, in general most of them could be prevented if the steel manufacturers could develop their processes of ingot making to such an extent that the shrinkage cavities could be avoided, and it may be pertinent at this point to call their attention to the fact that the method of producing sound ingots by use of sand top mold and other hot top devices was described by Sir Robert Hadfield, in the Journal of the Iron and Steel Institute, and reprinted in Vol. 14 of the Proceedings of the A.R.E.A. As twenty years have elapsed since that time, any patents on the process then described must have expired and manufacturers should now be free to develop the processes to the advantage of both themselves and their customers.

THE THEORY OF PROBABILITY APPLIED TO BRIDGE AND BUILDING LOADINGS

By B. R. LEFFLER

PRELIMINARY VIEWS

1. A moot question in designing railroad bridges carrying multiple tracks is the total loading. For a single track bridge, the maximum load is taken. For a double track bridge, up to recently, both tracks were taken with simultaneous maximum loads. For more than two tracks, Engineers have modified the track loading on the theory that simultaneous maximum loads on all tracks are highly improbable.

2. In designing office buildings, shall all floors be taken as simultaneously loaded with maximum loads for designing the basement columns and foundation footings? The table on page 333 of the Association's Manual of 1929 is an attempt at answering this question.

3. The word "probability" will be used in its mathematical sense and not in a loose and popular sense.

MATHEMATICAL PROBABILITY

4. Probability pertains to the occurrence of casual events. The rising and setting of the sun during the next few years are not a matter of probability, because they are not casual events. But if a coin is tossed, the appearance of a head is a casual event.

For our purpose, a casual event is one whose occurrence cannot be foretold.

Take a four-track bridge of three trusses. The middle truss receives its greatest imaginable loading when all four tracks are simultaneously and fully loaded. But the loading of all four tracks simultaneously is a casual event; more about this later.

5. Take a 30-story office building. The loading of all floors simultaneously with full live load is so highly casual that Engineers, long ago, have ruled that it is practically impossible.

6. As an example of casual events, the tossing of coins is taken to illustrate the Theory of Probability. If one coin is tossed, the probability of a head or tail appearing is ½; common-sense tells this. If more coins are tossed, the probability of a certain number of heads or tails is not easily seen by common-sense. For a precise statement of probability of many casual events, the reader is referred to works on Probability*. We will confine ourselves to applications of the Theory.

7. Suppose eight coins are tossed, then Merriman gives the probabilities of heads, as shown in Table 1.

* Merriman's Least Squares, 3rd Ed., is an excellent work.

TABLE 1.

Eight Coins Thrown.

Heads	Probability
4	70/256
5	56/256
6	28/256
7	8/256
8	1/256

Merriman has plotted these events to form a curve. Fig. 1 is this curve, with respective probabilities shown on the ordinates. Along the X axis are plotted the spaces corresponding to the heads.

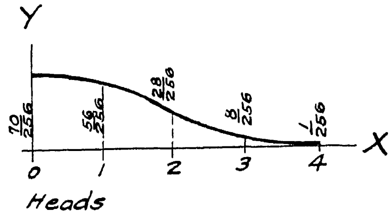


FIG. 1.

About 150 years ago, the equation for this curve was the subject of much seeking by the world's greatest mathematicians. Finally, there was found the following equation:

$$y = ke^{-h^2x^2} \quad \dots\dots (1)$$

in which k and h are unknown constants, which will be evaluated later, and $e = 2.718+$. The curve is known as the Probability Curve.

8. Let us see how the curve of the equation fits the curve for tossed coins, Fig. 1. We will take the extreme ordinates, namely $\frac{70}{256}$ and $\frac{1}{256}$, as given. This will enable us to determine values for k and h. It should not be necessary to give the intermediate steps; this will be done later. Finally, the equation takes the form:

$$\log y = -0.5632 - 0.115x^2 \quad \dots\dots (2)$$

Calculated values of the respective ordinates are shown in Table 2.

TABLE 2.

Heads	Probability	Remarks
4	70/256	Given
5	53/256	Calculated
6	24/256	Calculated
7	6.4/256	Calculated
8	1/256	Given

A comparison with the values in Table 1, or the values on the curve, shows a close agreement, and is evidence of the practical correctness of the probability equation.

PROBABILITY CURVE APPLIED TO A MULTIPLE TRACK BRIDGE

9. Let us apply the probability curve to a multiple track bridge loading, obtaining a curve similar to that for coins.

In Section 4, I compared the loading of multiple track bridges having simultaneous maximum loads to that of casual events.

Let us see. To produce the imaginable maximum stresses at any point of a bridge span, the following events must occur simultaneously on each track:

1. The position of the wheel loads must be identical on all tracks with reference to the point in question.
2. The impact must be the same for all loads, but entering into impact are a lot of other events, as follows:
   (a) The position of the locomotive counterbalances must be the same for all tracks.
   (b) Rail joints which cause impact must be of identical location on the bridge.
   (c) Flat spots on wheels or rails must produce simultaneous and equal effects.
   (d) Swayings of locomotives which are a cause of impact must be identical in amount and direction for all tracks, and occur simultaneously.
   (e) The speed of all trains must be simultaneously at the proper values.

In addition to the above events, it is now well-known that impact for spans of more than sixty feet is due largely to synchronous vibration of the span with driver rotation. This synchronous effect is highly improbable for bridges having more than two tracks, because the vibration of the span is dependent on the live load thereon.

Engineers, long ago, have recognized that the simultaneous occurrence of the foregoing mentioned events is practically impossible; in other words, they are casual events similar to heads coming up in the tossing of coins.

10. Coming now to a more concrete case. Take a short through plate girder bridge with one floorbeam only, located at the mid-point of the span. Suppose there are two main girders only, and that it is possible to have numerous tracks on the bridge. The floorbeam and girders will then receive their maximum stresses when the tracks are properly loaded. But, shall all tracks be under simultaneous maximum loads? In order to answer this question, the following assumptions are made:

1. That for any number of tracks, at least one track will receive the maximum load. The probability for one track is the highest.
2. That for a large enough number of tracks, at least one track will have no load at the time the other tracks are loaded. The probability of this track load is very small.

Assumption 1 is valid without a doubt.

Assumption 2 is not so apparent, and must be based on practical judgment. Section 23, page 1075 of the Association's Manual of 1929, is an interpretation of the assumption; it means that one track out of four is unloaded when three are fully loaded.

The greater the number of tracks across the imaginary plate girder span the smaller the probability of all tracks being fully loaded at one time. There is a practical certainty of at least one track being unloaded. It is further assumed that the bridge is not at a special location; as, in a yard, or near a depot. In short, all tracks are to be main tracks under unrestricted operation.

A SIX-TRACK BRIDGE CONSIDERED

11. In view of the casual nature of the events making up a loading as enumerated in Section 9, it is my opinion that, for six tracks across our imaginary plate girder span, at least one track will be always unloaded; or the probability of a sixth track being

loaded is very small. On the other hand, the probability of one track being loaded is one; one is the sign of absolute certainty in the theory of probability. We are, here, using the assumptions of Section 10.

Because the probability curve is asymptotic to the X axis, it will not do to assume a probability of absolute zero for the sixth track being loaded; but an infinitesimal-like number must be assumed. We will assume a probability of one divided by 100,000,000, as a practical working infinitesimal. Hereafter, "100,000,000" will be written "100 M".

As for the coin probability curve in Section 8, we have now two ordinates of the probability curve which will enable us to determine h and k of Equation 1.

In Fig. 2 the number of tracks are represented by spaces along the X axis; the track at the origin having a zero space. The ordinates represent the probability of the simultaneous track loads. The ordinate values in parentheses are the calculated probabilities.

The values of h and k are determined as follows:

When $x = 0$, $y = 1$ and k must equal 1.
When $x = 5$, Eq. 1 becomes:

$$\frac{1}{100\ \mathrm{M}} = e^{-25h^2} \qquad \text{or } \log \frac{1}{100\ \mathrm{M}} = -25h^2 \log e,$$

$$\text{or } -8 = -25h^2(0.4343).$$

Finally, $\log y = -0.32x^2$ as the working form of Eq. 1 for six tracks. Using this equation, the enclosed ordinate values of Fig. 2 are obtained.

Let us study Fig. 2. The ordinate for $x = 1$ means that for six tracks the probability of at least two tracks being loaded is 0.48. The amount of probability is nearly equal to that for a head appearing when one coin is tossed. For practical purposes, at least two tracks out of six will be simultaneously loaded.

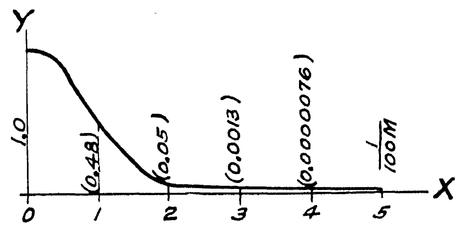


FIG. 2.

Take the ordinate for $x = 3$, the probability is 0.0013, which means that, when six tracks are considered, the probability of four tracks being simultaneously and fully loaded is fairly small.

Consider $x = 4$. The probability of five tracks being loaded is practically zero. In other words, for the six-track through plate girder span, two tracks should be considered as unloaded when the other four are fully loaded, in making the design. In fact, the probability of three tracks being fully loaded is very small; surely, four tracks fully loaded is ample.

A FIVE-TRACK BRIDGE CONSIDERED

12. Let us consider five tracks, using the assumptions of Section 10. This means that one track out of five will have a small probability of being loaded. Proceeding as for six tracks, the final form of Equation 1 is $\log y = -0.50x^2$. The probability curve is

shown in Fig. 3. The ordinate $x = 3$ has a very small value. This means that, if we are safe in assuming the fifth track as not being loaded, then the probability of the fourth track being loaded when the remaining three are loaded, is very small.

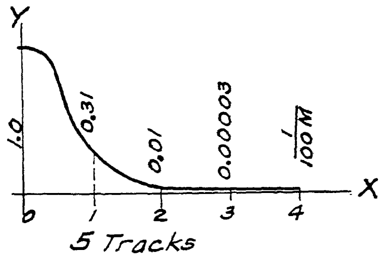


FIG. 3

It is to be noted that as the number of tracks across our imaginary plate girder span is decreased, the probability of the fourth track load also decreases.

We will illustrate this by the tossing of coins, as given in Merriman's Least Squares. If eight coins are tossed, the probability of four heads appearing is $\frac{70}{256}$. If six are tossed, the probability of four appearing is $\frac{60}{256}$. If four coins are tossed, the probability of all heads appearing is $\frac{16}{256}$.

When the casual nature of the events making up bridge loadings is considered, as outlined in Section 9, it should be evident that for practical purposes only three tracks out of five will receive simultaneous loads and no more tracks will be loaded when four tracks are taken.

For practical purposes, a track loading with a probability of one-ten-thousandth or less, indicates a track not loaded.

FOUR-TRACK BRIDGE CONSIDERED

13. Section 23 of the Association's Specifications says the loading shall be:

For two tracks —90 per cent.
For three tracks—80 per cent.
For four tracks —75 per cent.

The requirements give average loads, but since average loads do not produce the same shears and moments as the individual loads, the individual loads should be specified.

For a four track bridge, three tracks should be taken fully loaded and one unloaded. This three-track loading is in accordance with results indicated by Fig. 3.

It seems to me that Section 23 is closely in accord with the theory of Probability, if the individual loads are specified. The amount of probability should have a bearing on the respective track loads, especially when the heterogeneous character of the elements making up impact are considered. The clauses in Section 23 should then read:

For two tracks, one track 100 per cent, the other track 80 per cent.
For three tracks, two tracks 100 per cent and one track 50 per cent.
For four tracks, three tracks 100 per cent and the other track no load

HIGHWAY BRIDGE LOADINGS

14. A similar study can be made for highway bridges with wide roadways, say for four or more lanes of traffic.

Does it seem reasonable to consider a floorbeam in a six lane bridge as receiving simultaneous maximum loads from the six lanes including impact? The probabilities shown in Fig. 2 and 3 indicate that a marked modification should be made.

BUILDING LOADS

15. Consider a 30-story office building. If experience shows that one floor out of five receives its full live load and one out of five does not receive a simultaneous load, then the probabilities shown in Fig. 3 should govern. Accordingly, three floors out of five should be taken as fully loaded.

For the thirty stories, there are six groups of five. Hence, eighteen floors should be considered as fully loaded for designing the basement columns and foundation footings.

The table on page 333 of the Association's Manual does not extend far enough to include thirty stories; fifteen stories is the limit. For fifteen stories, the loading according to the Probability Curve should be nine floors fully loaded for the basement columns and footing courses. The table gives 8.9 floors, a rather close agreement.

However, for fewer stories the table is not in accord with the Probability Curve. I believe the table needs revision.

For a warehouse, the use of Fig. 3 may not be justified by experience.

FINALLY

16. In considering the subject, the reader should keep in mind that only casual events are considered. If by artificial means a track is purposely loaded, as may occur if a bridge is located near a depot or yard entrance, that track loading is not a casual event. The loading must be taken as surely occurring.

But even for such cases, the Probability Curve is of considerable value; it is practicable to use the curve to modify the load for tracks with small probability values.

THE RAILROADS

(I) In Retrospect
(II) In Prospect

By L. C. FRITCH

Vice-President, Chicago, Rock Island & Pacific Railway
Past-President, American Railway Engineering Association

(I) IN RETROSPECT

The Railroads are the backbone of transportation—now, have been and always will be.

The progress of civilization, commerce and industry depends upon the railroads, which have made possible the achievements of the past century. More has been accomplished during the past one hundred years in promoting civilization, wealth and prosperity on account of the pioneering of the railroads than in the preceding thousands of years.

Accepting as an undisputed fact that railroads occupy such an important place in our welfare, it is not conceivable that the people will permit the deterioration or destruction of this basic industry upon which depends our very existence.

Transportation is the most vital thing in our daily life. Suspend it for only a brief time and the suffering would be indescribable.

Railroads up to twenty years ago had a practical monopoly in the transportation field and as a result regulation in the public interest was necessary and justifiable. This situation has been changed with the advent of motor vehicles, which have taken an important place in this field, and of necessity have affected transport by rail. Temporarily, due to the lack of regulation of motor transport, there exists a conflict between the two methods of transportation, rail and motor, the former subject to minute and intensive regulation, the latter free from any form of regulation. It is only natural that until this new agency shall be economically adjusted to its proper sphere, including regulation in the public interest, difficulties will arise and affect the traffic on the rails; but in due time the public's interest will, without question, require that all forms of transport be regulated and each assigned to its economic sphere, and when this is accomplished the present difficulties will disappear.

At the present time we have a surplus of transportation. This is partly due to the business conditions now prevailing, and partly to an excess of transport facilities of all kinds to meet even maximum demands in good times. This is an economically unsound condition. The total transport facilities of the country at present represent an investment of about fifty billions of dollars, of which one-half represents the value of the railroads, and twenty-five billions the value of motor equipment, waterways, aeroplanes, etc. In the last analysis the public pays, and, therefore, a return must be made on this huge investment or defaults must result. The rail transport plant at the present time is only used to about one-half its capacity of three years ago, and its potential capacity is about three times its present use. Other forms of transport are likewise suffering because of the excess of transportation offered to meet the present reduced demands.

There is no question as to the ultimate outcome of the present evolution, or revolution, in transportation now in process, so far as the railroads are concerned. They always have been and always will be the most economical, dependable and necessary form of transport, and when the demand returns with good business, the present gloom surrounding the railroad industry will be dispelled.

Address delivered under auspices of Mid-Day Luncheon Club, Springfield, Ill., June 2, 1932.

A brief analysis will prove that the railroads occupy the premier position in the transport field. The freight traffic handled in this country in 1929, a good year, was divided as follows:

Steam Railroads	76 per cent
Great Lakes and Inland Waterways	16 per cent
Pipe Lines	5 per cent
Motor Trucks	2½ per cent
Electric Railways and other means	½ per cent

Take out the Great Lakes water transport and it leaves by land transport, Railroads 90 per cent and Motor Trucks 3 per cent. Therefore, the rails carried thirty times the freight traffic carried by the trucks in 1929. The cost of transporting freight one ton-mile by truck is estimated at 1.6 cents, including all operating costs, except interest on the investment. The same cost by rail is ¾ cents, or less than one-half the unit cost by truck. The economical radius of operation of the truck is from 100 to 150 miles; the railroad has no limit of economical radius of operation, but on the contrary the longer the distance handled, the greater the economy per unit of service, which is directly the reverse as applied to truck operation.

The only serious inroads made upon rail transport traffic by the trucks is in the so-called less-than-carload traffic, the total of that class of traffic being less than 2½ per cent of the total freight traffic. Much of this traffic, for short hauls, is not profitable to the railroads and its loss means no appreciable loss in net revenues.

While it is true that the inroads of the trucks on rail traffic of commodities of the car load class are increasing, principally in such commodities as cotton, coal, live stock, sand and gravel, yet owing to the longer hauls the trucks cannot compete with rail haul successfully, and regulation of trucks in handling such traffic will soon make it unprofitable for truck transport.

Future regulation of motor trucks on highways will undoubtedly fix a maximum load of around five tons, as engineering experience indicates that highways should not be designed for greater than five tons capacity on account of excessive cost of construction and maintenance. Some States, Texas for example, have a 3½ ton limit. With these low limits of capacity and regulations as to rates and service, which must come in the interest of the public, the future economical sphere of truck operation will be limited to a distance of 100 to 200 miles, and principally less-than-carload traffic within these limits, most of which the railroads would forego without appreciable loss in net revenue.

The trucking of freight on the whole has not been a profitable business, owing largely to the unregulated competition now in effect. Legitimate and responsible truck operators would welcome reasonable regulation, as it would stabilize this business and result in profitable operations, versus bootleg competition and serious losses.

With the trucking regulated and stabilized, railroads would engage in a co-ordination of truck and rail transport and successfully compete with truck operations, not only of owners, but contract and common carrier truckers, resulting in putting out of commission irresponsible trucks now operating at a loss and demoralizing the transport business, and which are a menace to the public in their use of the highways.

The railroads should have no quarrel with truck manufacturers and legitimate and responsible truck operators. They should cooperate in securing reasonable regulations governing highway motor vehicle operations, as well as promoting a coordination of rail and truck operations, that would be of benefit to the public, which it is entitled to and will demand, and patronize that form of transport which is most reliable and economical and meets their needs.

We hear much complaint from the railroads of the inroads made by motor trucks upon the traffic of the railroads, but there is another side of the picture in the large volume of traffic which the motor vehicles have contributed to the rails in the way of tonnage due to the manufacture of motor vehicles, related industries, construction of highways, etc.

The National Automobile Chamber of Commerce estimates that in 1930 the automotive industries and highway building contributed over 3,300,000 carloads of railroad freight, which represented 10.6 per cent of the total carload freight traffic transported by the railroads in that year. If these figures are correct, it more than offsets the loss in the traffic diverted from rail to motor truck transport.

The difficulties surrounding this problem are not insurmountable, but a solution can be found by sincere co-operation between the railroads, truck manufacturers, operators and users, to establish reasonable regulations as to use, service and rates, designed to allot to each form of transport its economical field of operation, as well as co-ordination between rail and highway transport, which would greatly relieve the congestion and destruction of highways, with ultimate beneficial results to all.

The early solution of this problem is eminently desired in the public interest, which is always paramount and in the end must be met.

A recent proposal has been made by some of the railroads that the Railway Express Agency, which is owned by the railroads, should take over and handle all the less than carload traffic of the railroads, in connection with truck operations, co-ordinating rail and highway transport and including pick-up and delivery service, thus giving to the public a dependable service, equal to or better than that which the present outside truck operators can supply, thereby recovering to the railroads a large part of this traffic which has been lost to the rails in the past few years.

The Railway Express Agency, owned by the railroads, has an investment of $9,500,000 in motor vehicles and operates 8,846 motors and 444 trailers in city service. The outside truck operations have made heavy inroads on the express traffic, the same as in the L.C.L. rail traffic. Much of its motor equipment is idle and, with its splendid motor truck service as a nucleus, it could handle all the less-carload traffic of the railroads and successfully meet the competition of the motor truck operators.

By co-ordinating rail and highway service a large part of the tonnage would be kept off the highways, reducing the cost of maintenance and construction of highways, thereby reducing taxes to the public, and render a more superior service to the public. Unless something of this kind is done, the railroads as well as the Express Company, will continue to lose their traffic to the motor trucks.

The cost of the present highway systems is a huge burden upon the public in the form of taxation. In 1929 alone this cost is estimated at $1,718,000,000—a tremendous sum, of which a large part could be saved to the public by proper regulation of motor service and keeping the heavy traffic off the highways and putting it on the rails, where it was designed to be carried.

The diversion of passenger traffic from rail to highways is far more serious than the diversion of freight traffic. Since 1920, when the passenger traffic was at its peak, there has been a steady decline in passengers handled, the decrease from 1920 to 1930 being 43 per cent. This is due first and foremost to the use of the private automobile, and second to buses.

The loss to the rails in short haul travel, approximately distances of 100 miles or less, has been greatest. A striking figure is the average miles travelled per person per annum, which in 1920 was 440 miles and in 1930 218 miles, or less than one-half.

The loss in passenger revenues indicates the vital effect which this has had on the revenues of the carriers. In 1920 the passenger revenues were $1,288,000,000; in 1930 $730,000,000, or a loss of $558,000,000, or 46 per cent.

There seems no possibility of recovering the losses sustained by the railroads to highway transport in its passenger traffic unless it is in meeting more fully the rates prevailing on buses, and by a reduction in present passenger rates to make it more economical to use the rails rather than private automobiles.

The present basic rate in passenger service of 3.6 cents per mile was a war-time rate. In Pullman cars, a surcharge of 50 per cent of the Pullman rate is made. Many complaints are made, and doubtless much passenger traffic has been lost to the private automobile and bus, on account of the present rates. Suggestions have been made and some experiments conducted to recover passenger traffic by reducing the rates in coaches to 2 cents per mile. Low rates for short periods of time have been put into effect to recover lost travel, but to no avail. The decline continues and it seems necessary to take drastic steps to make the travel by rail more attractive as to rates and service, but what definite steps to take has been the despair of the passenger traffic officials.

Many railroads favor a straight 2-cent per mile rate in coaches, with the establishment of the old mileage tickets to induce traveling salesmen to use the rails, and a 3-cent rate in sleepers, without any surcharge. The average rate in the Western District in 1930 was 2¾ cents, which would indicate that if present low rates of as low as 1 cent per mile were discontinued and a rate of 2 cents in coaches, and a 3-cent rate in sleepers established, the same number of passengers now carried would produce the same revenue, with the hope of largely increasing the number of passengers carried and, therefore, the total revenues.

Many who now use the private automobile no doubt would use the rails if the rates were reduced, and it seems that such a plan is worth a thorough test. Former tests were not comprehensive enough as to time and territory.

PIPE LINE COMPETITION

A greater menace to the railroads by the diversion of large volumes of freight traffic, than even the use of trucks to date, are the pipe lines which transport an increasingly heavy tonnage of crude and latterly refined oil, such as gasoline.

In 1929, in the Southwestern States alone, there were 50,000 miles of pipe line in service and during that year transported 728 million barrels, equivalent to 129 million tons of traffic. During the same year the railroads in the same region transported 3,250,000 tons. The revenues in 1929 of oil handled in pipe lines at 25 cents per barrel was 197 millions of dollars. Approximately 5 per cent of the total inland tonnage in 1929 was transported by pipe lines, or twice the tonnage transported by trucks. The railroads in 1929 transported only 4.5 per cent of the total oil production.

The investment in the 100,000 miles of pipe lines in the U. S., including main trunk lines and branches, is over two billion dollars.

The newest development of transporting gasoline by pipe lines is making further inroads upon railroad tonnage. Gasoline pipe lines now extend from Oklahoma and Texas to St. Louis, Omaha, Kansas City, Chicago, Milwaukee and Minneapolis. In the East pipe lines extend from the refineries at Bayonne, N. J., into Ohio and Pennsylvania. About 3,800 miles of gasoline pipe lines are now in service. These pipe lines operate in connection with trucks and barges, covering extensive terminal and lateral territory.

Another phase of pipe line competition with the railroads is the transportation of natural gas. There are now about 65,000 miles of natural gas pipe lines. These pipe lines gridiron the country tributary to the natural gas fields and for many miles in all directions. In the East, extensive natural gas lines traverse Ohio, Pennsylvania, West Virginia, Indiana and Kentucky, and Atlantic seaboard cities, Washington and north. In the Southeast and Southwest, the territory is thoroughly covered, reaching Chicago, Indianapolis, Macon, Ga., Pensacola, Fla. In the West, pipe lines extend throughout California, Arizona, Wyoming, Montana, North and South Dakota.

The increasing use of gas, as well as fuel oil, moved by pipe lines and tank steamers, has caused a substantial decline in coal tonnage previously handled by the railroads. In 1930 Pennsylvania produced 18 million less tons of anthracite than in 1920, and 15 million tons less than the annual average of 1909 to 1913. It is estimated that in 1929 natural gas alone displaced 77,500,000 tons of bituminous coal in the United States.

For many years the transportation of crude oil by pipe line had a serious effect, not only upon the tonnage, but the rate on crude oil and its products. Now we have an added competition due to the gasoline and natural gas pipe lines, which latter greatly affect the tonnage and rates on coal.

A further curtailment on the use of coal is the construction of central power plants, both water power and steam, with resultant transmission of electric power over widespread areas.

Ways and means of meeting this ever-increasing and intensive competition by pipe lines is of far greater importance than truck competition, and if the railroads shall survive, this competition must be successfully met, either by making such rates as will meet this competition, or taking over the pipe lines into a comprehensive transportation plan, which shall include all forms of transportation.

The transportation of oil or other commodities, except natural or artificial gas, by pipe lines is subject to the jurisdiction of the Interstate Commerce Commission. While these pipe lines, with the exceptions noted above, are considered common carriers and subject to the Transportation Act, no investigation has thus far been made to see if their operations are being conducted in the public's interest.

The economy of the gasoline pipe line has not as yet been demonstrated.

The Great Lakes Pipe Line Company has built a line from Texas to Chicago at a cost of twelve millions of dollars, or about $8,600 per mile. A parallel railroad handles at present about 9 per cent of the petroleum and is capitalized at about $50,000 per mile, or $4,500 per mile for petroleum traffic handled. This is only about one-half the pipe line cost. It is an open question if pipe lines for handling refined petroleum will be justified economically and practically.

WATERWAY COMPETITION

The water competitors of the railroads handle a substantial and increasing portion of the freight traffic of the country. The important services now rendered by water are:

Coastwise Domestic Service.—Operating between important Atlantic, Pacific and Gulf Coast ports. This service handled in 1930, 118 million net tons. It serves not only port-to-port traffic, but in connection with rail lines reaches far inland. For example, traffic is handled from interior New York and New England to the coast by rail, thence by water and on to the interior of the States in the Southeast and Southwest by rail.

Traffic as far west as the Missouri River, destined to Pacific interior points, is handled by rail or barge and rail to Atlantic and Gulf ports, thence through the Panama

Canal to the Pacific Coast and thence by rail to interior points. Similar movements occur in the reverse direction.

GREAT LAKES SERVICE.—Operating during the season of navigation (about seven months in the year), handled in 1930, 110,000,000 net tons of traffic. Formerly the railroads operated service on the Great Lakes in connection with rail lines, but were compelled by law to dispose of their vessels and discontinue this important and valuable service.

MISSISSIPPI AND WARRIOR SERVICE.—The most important service on these waterways is the Inland Waterways Corporation, owned, operated and subsidized by the U. S. Government.

It is the announced policy of the Government that it does not intend to permanently engage in water transportation, but only until such time as private capital will take it over and operate it. No private capital will ever be keen to engage in a losing enterprise and if the figures quoted showing a net loss in operations of the Federal Barge Lines and the Warrior River Terminal Company in 1929, of $72,798 are correct, the Government will continue to operate it and the taxpayers will make up the deficit.

The consolidated balance sheet of the Inland Waterways Corporation for the year ended December 31, 1930, shows assets of $19,111,000, in which is included $12,000,000 cash subsidy by the Government and the balance represents public property assigned to the Corporation.

The Corporation pays no taxes, nor any interest charges on capital expenditures made by the Government.

The Government has expended on the Mississippi–Ohio River system alone from 1824 to 1929 four hundred and sixty-nine millions of dollars for navigation purposes, of which the amount for new work, not including maintenance, is three hundred and twenty-two millions of dollars, or at the rate of $25,800 per mile.

The tonnage handled on the Mississippi River, between Vicksburg and New Orleans and between Cairo and Memphis, in 1930 was 12,000,000 net tons. On the Warrior River 1,500,000 tons, and on the Ohio River twenty-two million tons.

The cost of handling traffic on the Mississippi and Ohio Rivers in 1929 compared with the cost of rail transportation, *after all the elements of cost are included,* is as follows:

	Per ton mile
Mississippi River:	
Water	1.1 cents
Rail	1.0 cents
Ohio River:	
Water	1.2 cents
Rail	.9 cents

The taxpayer, and not the shipper, is making up the deficit in the cost of water transport, and always will. The average speed of barge transport is five miles per hour, by rail 15 miles per hour. The average distance between common distance points is 50 per cent greater by water than the direct rail route. Taking speed and distance into account, two points 400 miles distant by rail and 600 miles by water, would be served in 26⅔ hours by rail and 120 hours by water, or nearly five to one in favor of the rails, and at less ultimate or total cost per unit of service.

Waterways provide cheap transportation only when supplied and maintained by nature, free of cost, but when subjected to artificial means, such as deepening channels, constructing locks and dams and maintaining them, plus expenditures made under political administration, it is the most expensive transportation in the world, and no private concern would engage upon it, excepting on the natural waterways.

The New York Barge Canal is an example in point: The canal is 525 miles long, entirely within the State of New York, constructed, maintained and subsidized by the State. The cost from 1905 to 1930, not including the cost from 1817 to 1905, on which latter date it was improved, is the stupendous sum of one hundred and seventy-six millions of dollars, or at the rate of $335,000 per mile. The cost per ton-mile, all costs included, in 1929 was 19.4 mills, as against the cost, if handled by the railroads which parallel it, of 10.9 mills per ton mile, or about one-half. Only 3,600,000 tons of freight were handled in 1930. A railroad capable of handling this traffic could have been built for one-fourth the cost and could have handled the traffic at one-half the cost, as against the Canal operation. Furthermore, the New York Barge Canal is icebound as much as five months during severe winters.

The railroads have no quarrel with Waterways as such. They argue with justice that they should be free to all, including the railroads, which are barred from them, and that they should not be subsidized by the Government, nor embark upon competition and name a rate which is 20 per cent below the rail rate, and insisting that the water rate shall include *all elements of cost.*

The railroads are now prohibited from competing with water rates via the Panama Canal, which is depriving the railroads of millions of tons of traffic. Recently the Southern Pacific Railway applied to the Commission to reduce its rail rate ten per cent between New Orleans and Galveston and the Pacific Coast, to enable it to retrieve some of its lost traffic. This application was denied by the Commission on the ground that the railroad rate was not remunerative and yet thousands of empty cars are now being handled by the railroad company that could be loaded and handled at slight increased cost.

If the taxpayers knew the real facts about the cost of construction, operation, maintenance and subsidies of the Inland Waterway Development—the real cost of water transport, as the railroads know their costs, they would, to put it mildly, *be amazed,* and perhaps indignant, and insist upon stopping this waste of money.

TRANSPORTATION ACT OF 1920

The railroads were taken over by the United States Government January 1, 1918, as a war measure and operated as one system.

On March 1, 1920, their physical condition depreciated and with credit more or less impaired, they were returned to their owners.

In order to save the railroads it was necessary to pass legislation to aid them in the process of rehabilitation, and accordingly the Transportation Act of 1920 was passed, effective March 1, 1920, and was received with great acclaim as the most constructive legislation designed to preserve the integrity of the railroads which had been put into effect in the past twenty-five years.

The important features of the Act of 1920 are as follows:

1. It directed the Commission to initiate, modify and establish just and reasonable rates so that the carriers as a whole (or as a whole in each rate group, as the Commission may designate) will under honest, efficient and economical management and reasonable expenditures for maintenance, earn an aggregate annual net operating income, equal as near as may be to a fair return upon the aggregate value of the railway property held for and used for transportation purposes.
2. A plan for the consolidation of the railways into a limited number of systems.
3. It provided that if any road earned more than a prescribed return, one-half such excess shall be returned to the Government to be loaned to weaker roads on good security at 6 per cent.

4. It provided for arbitration and handling of labor disputes.

The Commission first fixed 6 per cent as a fair return for two years and on March 1, 1922, placed the fair return at 5¾ per cent. The Commission made a horizontal increase in freight rates in 1920 of 30 per cent, and on March 1, 1922, when it reduced the rate of fair return from 6 per cent to 5¾ per cent, reduced the rates 10 per cent.

It is an interesting point that the Commission, as its first act under the new law, fixed the tentative value of the carriers' property for rate-making purposes at $18,900,000,000, while the book value of the railroads' balance sheet at that time was $20,000,000,000, or a difference of only 5½ per cent, and brought down to date is only about 4 per cent. So that after nineteen years of laborious valuation of the railroads, in which the Government has expended about forty million dollars, and the carriers about one hundred and thirty millions, there is only a difference of about 4 per cent in the two valuations, showing the utter needlessness and absurdity of the minute and expensive valuation, which will never be ended and will remain a continual expense to the carriers and the taxpayers. As someone has aptly said, "The Railroad Valuation caused a mountain of labor and brought forth a mouse."

Has the Transportation Act of 1920 been carried out as Congress directed and as the public and the railroads had a right to expect?

The feature pertaining to a schedule of rates, initiated and adjusted by the Commission to enable the carriers to earn a fair return on their investment, has been a complete failure and is the direct cause of the condition in which the railroads find themselves at this time.

The Commission itself established a return of 6 per cent from March 1, 1920, to March 1, 1922, and 5¾ per cent thereafter, and it has not been changed since.

What has been the result? The rate of return has been as follows:

1920.....	.08 per cent	1924.....	4.2 per cent	1928.....	4.6 per cent
1921.....	2.9 per cent	1925.....	4.7 per cent	1929.....	4.8 per cent
1922.....	3.6 per cent	1926.....	4.9 per cent	1930.....	3.3 per cent
1923.....	4.3 per cent	1927.....	4.3 per cent	1931.....	1.9 per cent

In the ten years 1920 to 1930 the railways earned less than the standard rate fixed by the Commission of 5¾ per cent by an amount of $2,574,000,000. If the law had been carried out as Congress intended, the railways would have been able to pass through the present crisis without asking the aid of the Government to keep them out of bankruptcy.

The Commission has literally carried out the law with respect to the regulation governing the issue of securities and other regulations, restricting the activities of the carriers, but the most important feature remains unfulfilled.

The railroads were required to operate their properties honestly, efficiently and economically. Have they fulfilled their duty under the law, which is coupled with the requirement to enable them to earn a fair return on their investment?

From 1920 to 1930, $8,381,000,000 additional capital was expended in improvements to Roadway Equipment and Structures to produce more economy in operation.

The cost of freight transportation per 1000 revenue ton miles was reduced from $10.66 in 1920 to $7.43 in 1930.

The equipment capacity of freight cars was 41.9 tons in 1920, and 46.7 tons in 1930.

The capacity of locomotives in average tractive power was 35,789 in 1920 and 45,408 in 1930.

The fuel consumed in freight service was 197 lb. per 1000 gross ton miles in 1920 and 130 lb. in 1930.

The miles per car per day was 25.3 in 1920 and 35.7 in 1930.

The loss and damage to freight was 138 millions in 1920 and 38 millions in 1930.

The number of passenger fatalities in 1920 was 229, and in 1930, 61. The number of employee fatalities in 1920 was 2,578, and 977 in 1930. The number of passengers injured was 7,591 in 1920, and 2,666 in 1930. Employees injured in 1920 totaled 149,414 and in 1930 this total was reduced to 35,872.

The average speed of freight trains was increased from 11 miles per hour in 1920 to 15 miles per hour in 1930.

These accomplishments indicate that the railroads have fully complied with the requirements of efficient and economical management.

As to the honesty of the management, the fact that every activity of the carriers as to the accounting, rate-making and their application to issue certificates, and every other phase of their operation is minutely prescribed and policed by the rules and orders of the Commission, so that any dishonesty is promptly detected and punished, leaves no doubt as to this requirement having been fulfilled.

Attesting to the efficiency of railway service, Secretary Lamont, in his recent annual report, states:

> "At present it takes only one-half to two-thirds as long to move goods a given distance as it did a decade ago. The increasing efficiency with which traffic is handled has enabled producers to make quicker deliveries and distributors are able to carry smaller stocks and turn over their capital more quickly."

The savings in interest on capital involved in goods in inventory is estimated at over 100 millions of dollars annually, equivalent to about 2½ per cent on the total freight charges paid.

INTERSTATE COMMERCE COMMISSION

The Interstate Commerce Commission is the most powerful governmental regulating body in the world.

It has under its direct control the destinies of the capital invested in the railroads of the country, estimated at twenty-five billions of dollars, and indirectly the welfare of the 70 million insurance policyholders, investors in railroad securities, banks and trust companies; in fact, their decisions affect every man, woman and child in this country.

This grave responsibility is exercised by eleven men who are appointed by the President and confirmed by the United States Senate. There is no more conscientious and hardworking body of men in the public service. They have rendered valuable service to the public in guarding its interest, which is paramount; they have elevated the standard of ethics of the railroad profession, until it stands first; they have protected even the railroads from aggression among themselves, and they have changed the former hostile attitude of the public against the railroads.

The Commission realizes now that the railroads hold no monopoly on transportation; that the railroads are worth more than their capitalization, and, most important, that the present rate structure is not adequate even in fairly prosperous times to afford a fair return, and they respect the inviolability of private capital.

It is possible that owing to the varied and infinite details devolving upon the Commission, under their interpretation of the law, under which they are created and function, their perspective may be distorted and in their zeal to protect the public's interest they are unable to accord the carriers the measure of justice to which they claim to be rightly entitled.

The Commission claims that many of the ills of the carriers are of their own making and if they are not content with things as they are they should apply to Congress for relief in the form of legislation to modify their functions.

It is clear that the functions of the Commission are too broad and voluminous, and beyond their physical ability to perform, distracting them from the essential duties of protecting the public's interest and at the same time rendering justice to the carriers and the large and important interests which they represent.

It is certainly in the public interest that the railroads shall be preserved to serve the people adequately and economically. The Commission's interest, as well as that of the public and the carriers, would be conserved by the elimination of many regulations, rules and investigations which serve no useful purpose.

The valuation of the railways is a case in point, inaugurated in 1913, nearly twenty years ago. It has cost the people and the carriers nearly two hundred millions of dollars, is not yet completed, never will be, and could have been determined by the Government's accounting forces within four per cent of the results obtained in years of laborious effort. The law should be repealed.

There are various rate hearings, such as the class rate and grain rate cases that drag their course through four to seven years before decisions are reached, and when reached conditions have changed that nullify the decisions.

A lesson might be learned from our friends, the Board of Railway Commissioners of Canada, which decides cases quickly and without the delay and its ill effects that obtain under our procedure.

The public is demanding a change in the function of Government Bureaus and it would receive responsive consideration from the Commission, as well as from the railroads, if the duties and functions now prescribed by law were modified and simplified.

(II) IN PROSPECT

What is in prospect for the future of railroads?

The problems of agriculture and the railroads are two of the most important questions confronting the country at this time. Upon the solution of these depends the welfare of our country at this time.

One-half of our people depend directly upon agriculture and one-half upon the railroads. Indeed agriculture is even more dependent upon the railroads than upon any other industrial activity.

Our population of 123 millions are active, virile and energetic, with the greatest potentiality as producers and consumers of any like population in the world.

In natural resources we are one of the greatest, if not the greatest nation in the world—with coal, oil, timber, precious metals and minerals in vast stores.

The gross income from leading crops last year was more than seven billions of dollars.

Savings deposits are at a record peak of over 28 billions of dollars and the number of depositors at 59 million, or 40 per cent of the entire population.

Life insurance policies total 109 billions of dollars, with millions of holders—the largest volume in our history.

We have about five billions of dollars in gold piled up in our National treasury.

With all this plethora of wealth and resources we are passing through a crisis—the most severe in the history of our Republic.

The same characteristics that founded this Nation and created the greatest Republic in the world, despite difficulties which, in comparison to those confronting us today,

seemed insurmountable, will carry us safely through the present crisis to even greater achievements than any heretofore accomplished.

It is inconceivable that in the solution of our problems a people, who are so vitally affected by the most basic industry—the railroads—which was created by them and for them and is actually their own, will permit the destruction, or even the deterioration, of this vast enterprise.

An abiding faith in the ultimate justice of the American people is a guaranty that that will not and shall not be done.

The people must be aroused to the seriousness of the situation as it confronts the railroads.

What would happen to the millions of policyholders of billions of dollars in insurance; to the millions of holders of billions of dollars in savings banks and trust funds; to the millions of railroad securities holders, if this basic industry became insolvent? It would result in the greatest calamity that could befall this Nation since its birth; and could easily mean the destruction of our civilization.

History records that crises are never averted until the people are made cognizant of and thoroughly aroused to a situation, and then with grim determination act swiftly to avert a calamity.

There is precisely such a situation confronting the people at this time respecting the railroads.

In the short period of a century they have built up a magnificent machine with their own investment of 25 billions of dollars, affording employment and subsistence to a vast army of fine citizens. The splendid machine has served them well, created their wealth, contributed to their happiness and welfare.

Shall this basic industry be discarded for new forms of transportation which have suddenly developed and are encroaching, without control, upon the legitimate field and threatening the very existence of the railroads?

The verdict is entirely in the hands of the people, but their's likewise will be the responsibility for the results.

The majority of the people do not want Government ownership of and operation of railroads. From the experience of the wartime experiment it would prove expensive and demoralizing to the commerce of the country.

In taxation, immediately about 400 millions of dollars in taxes would be withdrawn, increasing the public tax burden by that amount. It would build up a political control that would be disastrous. Unless something is done to come to the aid of the railroads and the present conditions of unregulated competitive transportation continue, the possibility of Government ownership and operation looms large on the horizon.

The solution is so simple—and the people are beginning to slowly realize it—it lies in the proper and reasonable regulation of all forms of transportation.

The railroads have been, and are, regulated to the point of strangulation. The other forms of transportation are permitted to operate without practically any regulation.

What Abraham Lincoln said of slavery is equally true of transportation. He said "No Nation can live half free and half slave." Likewise it can be said commerce and the Nation cannot prosper with one-half of the transportation, the railroads, with an investment of 25 billions of dollars, regulated to the minutest degree, and the other half, likewise an investment of about 25 billions of dollars, practically unregulated.

When the people begin to realize that we have in this country about 50 billions of dollars invested in transportation, which is more than the country can economically support even in prosperous times, and that the losses resulting from the economic waste

come out of the pockets of the people in some form or another, they will begin to appreciate the necessity of doing something about it.

The railway employees are doing their utmost to sound the alarm and acquaint the people with the dangers confronting them, but are met with charges of bad faith and as propagandists in their own selfish interest.

Under our form of Government there is guaranteed to all equal rights under the law, the rights of persons and the rights of property. If one class of persons, or one class of property, is restricted in the enjoyment of these rights, and another class is without restrictions, then there is no equality under the law, and injustice is done to the regulated class.

This is precisely the situation which confronts the people today in regard to transportation—the greatest necessity of our daily life.

The railroads do not ask charity or favors. All they ask is justice and equality under the law, alike to all, without favor or discrimination, and that they too be allowed the same guarantees of the right to life, liberty and the pursuit of their own business, that is now being denied them, knowing full well that they can meet any form of competition that may present itself, if it is fair, open and above-board.

RAIL GAGE PLATE ADOPTED BY THE SOUTHERN PACIFIC COMPANY

By W. H. Kirkbride

Chief Engineer, Southern Pacific Company, Pacific Lines

While the use of preservative treatment of railroad ties has effected large economies through the prevention of decay, all of the benefits of this treatment are not being fully realized due to the mechanical wear and destruction of the ties before decay necessitates their replacement.

Our records indicate that of all treated ties removed from track, forty to fifty per cent of these removals were due to causes other than decay.

While mechanical wear affects the life of wood ties in nearly all locations, it reaches a maximum and becomes a serious problem in territories where the curvature is sharp and the volume of traffic is heavy.

Under these conditions, the mechanical wear may so shorten their life as to prevent the economical use of treated ties.

This has been the experience of the Southern Pacific Company on its mountain grades. In this curved track territory, the service life of the tie is determined by destructive forces other than decay.

Experience has shown that under heavy traffic, the life of fir and pine ties on curves of eight to ten degrees was about three years. Consequently, the use of creosoted ties, or ties treated by other preservative processes, was not justified and untreated ties were used.

Not only was the life of these untreated ties shortened to about one-half of the natural life of untreated fir, but also the opportunity of securing the economies of a long life by preservative treatment was lost.

Studies made in an endeavor to find corrective measures for this mechanical destruction showed that it was occasioned by combinations in varying degrees of the following repeated processes:

(1) The tipping outward of the rail under the thrust of locomotive drivers and car wheels, resulting in the widening of the gage and in the rail cutting of the ties. This necessitates the repeated adzing of the tie and respiking of the rail.

(2) The widening of the gage by the curve wear of the ball of the rail, necessitating regaging.

(3) The respiking of the ties due to the renewal of the rail on curves.

(4) The abrasive action of the tie plates on the tie, due to a lateral and horizontal movement and to a vertical, or teetering action of the plate, this action being augmented by grit and water accumulating between the plate and the tie, particularly on the mountain grades where large quantities of sand fall upon the plate from locomotives incident to sanding the rail, resulting in tie plates, aided by these abrasive agents, wearing away the wood fibers and embedding themselves into the tie.

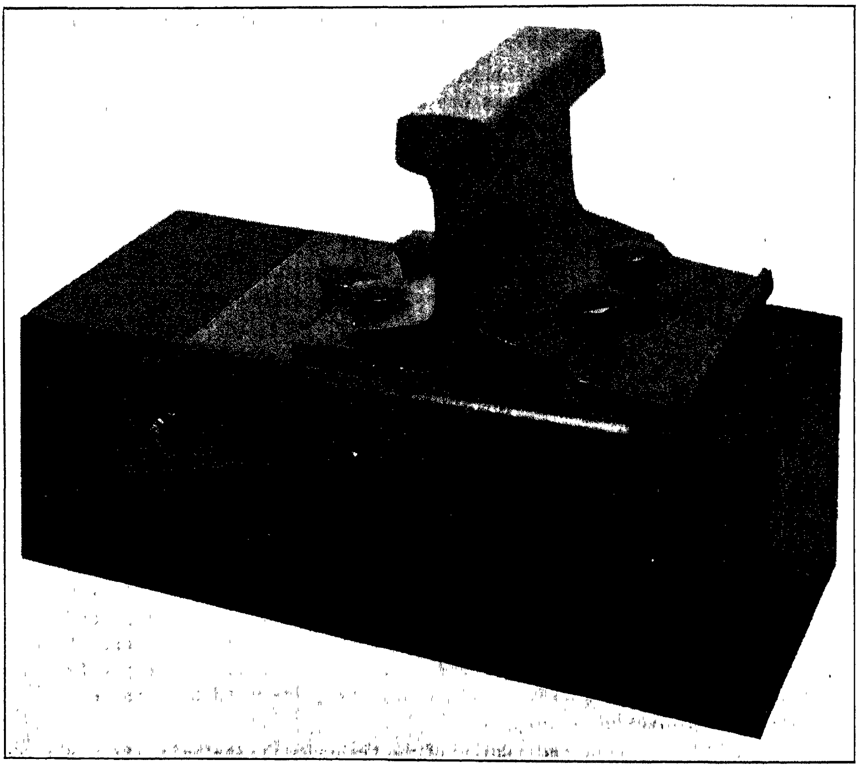
(5) The brooming and splitting of the ties under the shattering effect of heavy axleloads.

Not only did these various processes seriously decrease the life of the tie but they combined to increase the frequency and amount of resurfacing and relining of the track.

The use of canted tie plates, heavier rail and rail anti-creepers assisted to decrease these destructive processes, but only about to the extent that they were being increased by longer locomotive wheelbase and heavier axleloads.

Experiments as to preventive measures which could be taken, led to the design and test of the Rail Gage Plate. This plate is illustrated in photograph No. 1 and consists of a steel plate which conforms in width to the tie, but is several inches longer than the tie plate to be used. Two flanges project downward along the side of the tie, through which a bolt is inserted. An upturned outer end flange engages the outer edge of the tie plate.

The gage plate is supplementary to the tie plate and is placed under the tie plate and directly on the tie. It can be applied level with the top of the tie or the tie can be adzed, depending upon the amount of cant that is desired in the running rails. It is fastened to the tie by means of a bolt passing horizontally through the downward side flanges and the tie.



PHOTOGRAPH No. 1.

Model illustrating application of Rail Gage Plate showing ensemble of rail, canted tie plate, the rail gage plate, and tie.

Spike holes are provided in the gage plate conforming to the punching of the tie plate in use. These holes are so spaced that when the outer edge of the tie plate is hard up against the outer upturned end flange, the rail-holding spikes can be driven to perform their usual functions. An additional spike is provided for at the inner edge of the tie plate to hold the tie plate tight against the outer end flange and prevent vibration and also to assist in holding the gage of the track.

The process of manufacture is simple, involving only shearing, punching and forming machinery. The plates are cut from metal sheets of commercial width and length and so laid out on diagonal lines that very little waste of material occurs except from the punching of the spike and bolt holes.

The first installations on the Southern Pacific Lines were made in 1926 on ten-degree curves on the mountain districts carrying heavy tonnage. Untreated ties were used and these were pre-adzed and bored. The bevel of the dap was sufficient to provide a 1 in 20 cant to the rail when the standard tie plate, which is canted 1 in 44, was placed on the plate.

These test installations soon showed a decided decrease in the mechanical destruction of the tie and also a large decrease in the labor incident to the adzing, regaging, lining and resurfacing of the track.

Inspection showed that the rail was being held to its proper position and curves which formerly required regaging twice a year were remaining in proper gage.

Six years' experience has proven that the wear on the rail head, due to the action of the flanges of the wheels, has had but little effect on the gage of the track as long as the rail is held in its normal position with respect to the tie and its base kept at true gage by means of the rail gage plate. Further experience showed that where it was necessary to transpose or relay the rail on the curve, this could be accomplished without removal of the outside spikes or the adjustment of the gage plate as these had remained at proper gage.

Photograph No. 2 shows one of these original test installations on the Sierra Nevada Mountains where the gage plates were installed in December 1926 on a ten-degree curve, under 110-lb. rail in the west-bound main track.

In November 1928, the 110-lb. rail was transposed from outside to inside and in July 1930, was replaced with 130-lb. P. S. Section. Each of these rail changes was made without a change in the gage plate. The original ties are intact and have now been in service six years and one month, or twice the life formerly obtained from these untreated fir ties.

Photograph No. 3 shows one of these ties which was removed in March 1931, for inspection purposes and indicates that the elimination of mechanical destruction has practically been accomplished.

Tests made using creosoted ties indicated that with the gage plate, treated ties can be used on sharp curves and obtain the economies of the long life afforded by the preservative treatment and that these ties will remain in track for many years without the necessity of regaging.

As the result of these tests the Rail Gage Plate was adopted as standard by the Southern Pacific Company in December 1930 and since that date is being used on all the heavy traffic lines for the protection of track ties on curves, also for bridge ties on steel spans. Present tests indicate that economies also can be obtained by their use in tangent track which is subjected to heavy traffic and heavy power.

PHOTOGRAPH NO. 2.

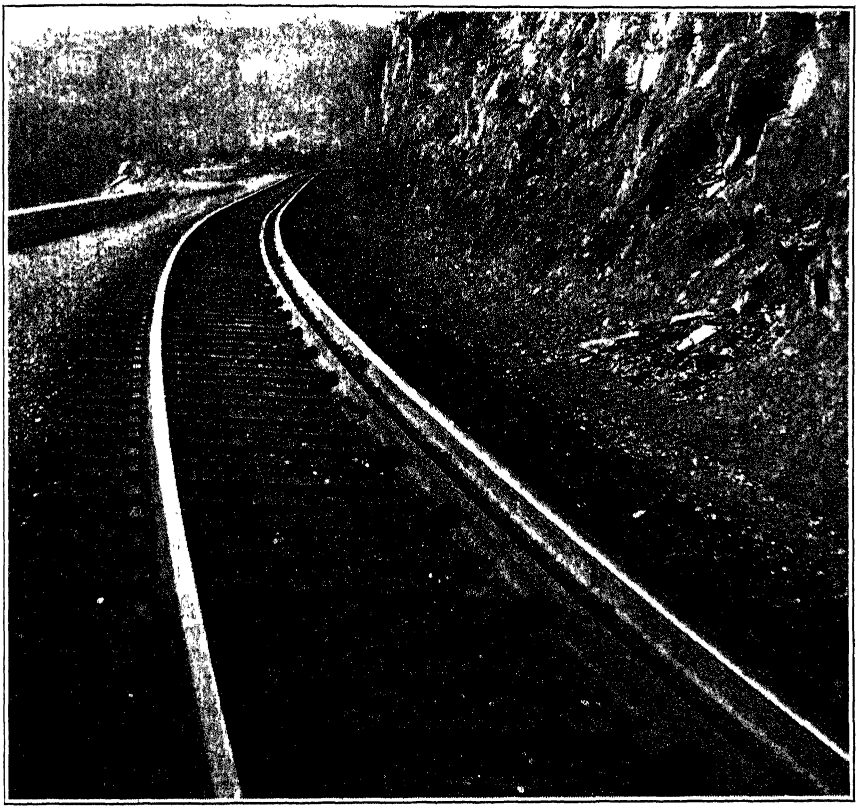
Illustrates application of rail gage plates on Southern Pacific Company, Pacific Lines. These plates are on ties in the westward main track on a 10-degree curve near Colfax, California. Plates were installed in December, 1926, under 110-lb. rail which had previously been laid in the same year. In November, 1928, the 110-lb. rail was transposed from outside to inside and in July, 1930, the 110-lb. rail was changed out to 130-lb. P.S. Section rail. All of this work was done without change in the gage plates. These same ties have now been in the track six years and one month.

PHOTOGRAPH NO. 3.

Untreated fir tie, equipped with rail gage plate, removed from same 10-degree curve shown in Photograph No. 2 near Colfax, California, on westward main track of Southern Pacific Company. The other ties on this curve all equipped with plates, are in similarly good condition, having now been in the track for six years and one month, having been installed in December, 1926.

The Southern Pacific Company operates its own creosoting plants and ties are incised and spike holes bored before treatment; the spacing of the spike holes being determined by the weight of rail and degree of curve where the ties are to be used.

For application of rail gage plates the ties are also adzed by a revolving cutter to provide a seat for the gage plate; the top being beveled sufficiently to provide 1 in 20 cant to the rail when the tie plate with a cant of 1 in 44 is placed on the gage plate. By the use of a gage clamped to the tie and air



PHOTOGRAPH NO. 4.

Application of gage plates. Cape Horn—Eastward track, Curve 150, looking west. Showing curve gage plates with guard rail installation. Plates installed October, 1929. Picture taken December, 1930.

operated bits, the horizontal bolt holes are drilled to their exact location relative to the spike holes. The ties are then creosoted and shipped to the track forces upon requisition. The rail gage plates and bolts are shipped by the Stores Department direct to the job and are applied in the field by the track forces. As these installations are made during tie renewals or other track replacements, very little additional labor is necessary.

When found desirable to apply the gage plates to ties already in the track, this can readily be done by cribbing out a small amount of ballast and boring a horizontal hole in the tie by means of a light weight hand boring machine, such as we use in check-bolting ties in track. The gage plate is then applied and bolted to tie, tie plate inserted and spikes driven. It is also possible to apply creosote oil under pressure to the newly bored bolt holes by means of a small portable tank actuated by a hand pump. The oil under pressure is applied through an alemite connection to the tie.

Washers made from the plate scrap are furnished and in cases of an undersize tie a washer can be inserted between the tie and the flange of the plate on one or both sides of the tie, to afford a close fit when the bolt is tightened. With sawn ties these washers are seldom necessary.

It was expected that strain on the bolt, in the course of time, would elongate the diameter of the hole in the tie and a small beveled semi-circular shim was provided which could be inserted in the hole under the head and nut of the bolt, to take up any play which developed. Experience to date has shown no elongation of these holes and the use of these beveled shims has been unnecessary.

The benefits which have been obtained from these rail gage plates may be summarized as follows:

(1) The rail is held rigidly to its established position and wide gage or spread track is prevented.

(2) The tie plates maintain their true position in relation to the rail with the shoulder tight against the rail base.

(3) The ties are protected from the abrasive action of the tie plate.

(4) Spikes are driven vertically and to true gage position when first installed and act in unison in resisting the thrust of the wheels.

(5) The wood fibers in the upper part of the spike hole are protected from severe stress due to the initial pressure of the tie plate against the top of the spike by the substitution of the metal between the tie plate and the tie.

(6) The canting over of the rail with its accompanying dangers of spread track is prevented by the holding of the ball of the rail to its true position relative to the wheel treads, thus securing the maximum service life of the rail.

(7) The horizontal bolt of the gage plate acts as a check bolt and with the downward side flanges of the plate, boxes in and binds the vertical fibers of the tie, preventing its splitting and brooming.

(8) By the elimination of the mechanical destruction of the tie, its service life is prolonged. This permits the use of treated ties in curved track and obtains the economies of the preservative treatment of these ties. In addition, this elimination of mechanical destruction results in a saving of track labor previously expended in track repairs which were made necessary by this same mechanical destruction.

The savings to be made by the use of this rail gage plate depend upon the cost and kind of available ties and upon labor rates of pay. Large savings in labor and material have resulted in the curved territories in which they have been applied and a conservative estimate indicates that a saving of 25 cents per tie per year is resulting from the use of creosoted fir cross-ties equipped with these gage plates, as compared to the use of the untreated fir tie with only the ordinary tie plates.

DISCUSSIONS

DISCUSSION ON UNIFORM GENERAL CONTRACT FORMS

(For Report, see pp. 125–129)

Mr. F. L. Nicholson (Norfolk Southern):—The report of the Committee on Uniform General Contract Forms will be found on page 125 of Bulletin 349. The report of this Committee is one almost entirely of progress.

The subjects assigned and now under consideration by the Committee are of such nature as to require collaboration with other committees of this Association, and in addition thereto conferences and correspondence with other organizations, having to do with the use of such forms, with the view to reconciling, as nearly as possible, the differences of opinion and interests, thus when the forms are completed and ready for action by this Association they will be acceptable as a fair guide or base from which contracts or agreements may be prepared to cover any local condition, and can be used, in most cases, in the exact form as recommended. It should not be expected, however, as some seem to think, that this Committee can secure in every instance the unqualified approval or adoption of such completed forms by other organizations—where interests differ, opinions likewise differ. Because of these difficulties in preparation of the forms, the Committee's report is largely one of progress, which assuredly is being made in all subjects.

As to Revision of Manual, we have nothing to report at the present time.

Subject 2, Form of Agreement for the Purchase of Electrical Energy in Large Volume (such as required for traction purposes), has been in hand for several years. The Committee has been dealing with various organizations interested and considerable progress is being made. At the last meeting we offered a tentative form and asked for suggestions. We have received a number. The Committee is very well pleased with the result of presenting that tentative form last year.

Subject 3, Form of Conveyance of Title Granting the Right to Construct and Maintain Air Right Buildings over Railway Property, is in the hands of Mr. O. K. Morgan. The Sub-Comm'ttee reports progress. Mr. Morgan, Chairman of this Sub-Committee, has been very ill during the entire year.

Subject 4, Form of Agreement for Pipe Line Crossings under Railway Tracks, and Subject 5, Use of Railway Property by Pipe Lines, etc., will be reported on by Mr. A. A. Miller, a member of the Sub-Committee having these subjects in hand; Mr. Charles Silliman, the Chairman, being unavoidably detained in Washington.

Mr. A. A. Miller (Missouri Pacific):—The report of Sub-Committee 5 will be found on page 127 of Bulletin 349. This report is submitted as a matter of information.

Effort is being made to cooperate with the American Petroleum Institute and Committees I and XIII. A conference has been held with representatives of the American Petroleum Institute and the general approval of Committees I and XIII has been obtained.

Since this Bulletin was issued the Committee has been in conference with representatives of the American Petroleum Institute and we feel that at this last meeting with them considerable progress was made. I feel very sure that we are at least 90 per cent of the way, and while this report is being submitted to you as information, we invite any criticisms, suggestions or other help that you might care to give to the Committee.

I feel, as I said before, that real progress was made in the last contact with representatives of the Petroleum Institute.

The President:—Possibly someone would like to ask about that meeting with the American Petroleum Institute. I believe you had a conference with them in St. Louis about the second or third of February, didn't you?

Mr. A. A. Miller:—Yes, sir.

Chairman F. L. Nicholson:—About the first of February a conference was held in St. Louis between a Sub-Committee representing the Roadway Committee, a Sub-Committee representing this Committee, and a committee representing the American Petroleum Institute. The specifications prepared by the Roadway Committee and the tentative contract form now submitted by this Committee were discussed. It is thought that satisfactory adjustments of differences will be made.

Mr. A. A. Miller:—At this meeting with the representatives of the American Petroleum Institute we were met with a viewpoint that no contract form was really needed; that the entire matter had better be left open-ended, so that those negotiating agreements covering a proposition of this kind would not be faced with any suggested requirements in the form set up and recommended for general use. In other words, a wide-open field was wanted on each and every occasion. We took the position that it was within our right and province to set up a proper form for general use and it might be possible to harmonize their views with ours in preparing a general contract form.

After considerable discussion, I rather think that the matter is not so full of confusion as it was. In other words, there is some direction being given to it. We are hopeful that we are going to harmonize viewpoints and we expect to put into the Manual a general contract form that will be satisfactory.

The President:—Does anybody here wish to ask Mr. Miller any questions?

Mr. Robert H. Ford (Rock Island):—It would be of value if the Committee would report a clause which should provide that when railways participate in public improvements, the transportation of men, materials and supplies, will so far as possible (or practicable) be routed over the rail carriers, especially those directly contributing to these costs.

It does not require much reflection to see that the railways are being asked to contribute to the up-building of competing agencies to be used by trucks and busses in transportation of goods and persons for hire. In this way the railroads lose their business; meanwhile, they are being required to contribute in the form of additional taxes account of being large property owners, and they must also contribute to the cost of the improvement.

The President:—Mr. Ford, this Committee as well as the Outline of Work Committee will take that into consideration.

Mr. W. A. Radspinner (Chesapeake & Ohio):—I think there ought to be included in that agreement a space to show the maximum pressure under which that pipe line should be operated. There are cases now of low pressure natural gas lines being converted into high-pressure gas lines. Unless there is some maximum pressure under which those lines may be operated there is a possibility of having explosions when the change is made.

The President:—Are there any other questions? This Committee, as well as the Committee on Outline of Work will take those matters into consideration.

Chairman F. L. Nicholson:—I should like to say that the Committee has already taken those matters into consideration. Meetings have been held, as we have stated, since this report was printed. Your suggestion, Mr. Radspinner, is under consideration and will be embodied in the report.

As to Mr. Ford's suggestion with reference to the last subject, we are now taking that up. The tentative form which we have already prepared contains Mr. Ford's suggestion. We have thought of that.

Subject 6—The form of Agreement with Public Authorities for Highway Grade Crossing Elimination or Separation is a subject that we thought we must approach very carefully. After the subject was assigned, we received a number of letters protesting against taking any action in this matter. Why railroad men are so fearful of taking

action on committee-work that in any way affects a public authority I cannot understand.

Those who wrote to us seemed to have the idea that we intended to incorporate in the contract form an exact division of the cost. That was never intended to be written in the contract form. You do not fill in your unit prices when you draw a contract until you have had your bids and agree on prices. Spaces are left in the form for such things. The Committee never had any intention of writing in the division of cost. We thought there should be an investigation, however, to ascertain just what was being done in every State of the Union with respect to these matters. Another Committee, the Committee on Grade Crossings, we found was handling that phase of the matter. Our Committee did not pursue it. The Committee on Grade Crossings will report at this meeting. They have prepared a very comprehensive report. You will find that there is no consideration being given by any of the states to present-day conditions. Most of them are dividing the costs on the 50-50 basis, which is manifestly unfair to the railroad under conditions where we have transportation companies operating on the highways and they, by their operation, are bringing these things to pass. They are hastening grade crossing separations where, in the ordinary course of events, they would not be required.

The Committee has, because of these objections to which I am now referring, been somewhat hampered. We have had to explain to many what we are trying to accomplish. This Committee has never been hasty in drawing its conclusions. They invariably make one or two drafts of their reports to this Association for criticism before anything final is done, but they do feel if there was ever a need for a standard form it is for one that can be used in dealing with public authorities. With such a form before us we may, if we will work together (which we at times find a very difficult thing to do), so influence the state legislatures that they may give us a fair deal.

The President:—Does anybody else have anything to say or to ask the Committee?

Chairman F. L. Nicholson:—I should like to say just this: This Committee, in formulating its draft for contract forms, gets its information from the railroads, members of this Association, in the first instance. If unable to get such information, or if there is no information available from the railroads, they get the best they can elsewhere and draft their own contract forms. Those forms are then submitted to this Association. The matter is never taken up with outside bodies unless this Association has passed on it and, up to the present time, not until we have been instructed to confer with other associations beyond the railroad organizations. I just make that explanation so that you will understand the methods pursued in arriving at these contract forms.

That is all we have to report.

The President:—Mr. Nicholson, this Committee has been doing effective work in this Association, and the Association appreciates it. That work has been going on for a good many years. In regard to attacks from people in Washington—this Committee has been trying to help me put over some of these things. I think we are rather clarifying that situation there a great deal.

I want to thank this Committee for what they have done. I admire their spirit. The Committee is dismissed with the thanks of the Association (Applause).

DISCUSSION ON WOODEN BRIDGES AND TRESTLES

(For Report, see pp. 65–74)

Mr. H. Austill (Mobile & Ohio):—The report of Committee VII—Wooden Bridges and Trestles is found on page 65 of Bulletin 349 and is largely a matter of reporting progress due really to no fault of this Committee.

Mr. Smith, Chairman of the Sub-Committee on Revision of Manual, is not present and I will present this part of the report.

The first revision is that of definition of a Screw Pile, which now occurs on page 450 of the 1929 Manual. Since the publication of this, the Committee has received a letter from Mr. E. E. R. Tratman, in which he offers the following substitute for the definition recommended by this Committee:

"Screw Pile.—One driven by rotary movement instead of by impact and having a broad-bladed screw attached to its foot to bore its way into the ground and also provide a large bearing area."

The Committee is perfectly willing to accept that substitute if it is the wish of the convention.

The President:—Colonel Austill, do you want to make these changes one by one or as a group? Which would you prefer?

Chairman H. Austill:—There is just this one definition.

The President:—Do you make a motion to that effect?

Chairman H. Austill:—I will so move, that the definition offered by Mr. Tratman be substituted for that printed in the Bulletin.

(The motion was put to vote and carried.)

Chairman H. Austill:—The other revisions appearing on pages 66, 67, 68 and 69 pertain to changes in present timber specifications and, except for that pertaining to the pile, are changes really by the A.S.T.M. committee, with which we are merely cooperating, and are offered to clarify and make more definite the matter which is now in the Manual.

Do you wish those covered paragraph by paragraph or to be acted on as a whole?

The President:—We can act on them as a whole, if there is no objection.

Chairman H. Austill:—I move that the changes submitted on pages 66, 67, 68 and 69 be adopted.

The President:—Are there any questions? Are there any remarks?

(The motion was put to vote and carried.)

Chairman H. Austill:—On subject (2) Simplification of Grading Rules and Classification of Timber for Railway Uses, Mr. Hawley is absent. This is a matter on which we report progress.

The President:—Colonel Austill, isn't that Sub-Committee also going to work with that new Manufacturers' Committee that is to be appointed?

Chairman H. Austill:—We act with and cooperate with any and all Committees with which we can get in touch and which are handling the subject.

On Subject (3) Overhead Wooden or Combination Wooden and Steel Highway Bridges, Mr. Hart is absent. This is merely a progress report and will be so offered.

Subject (4) Design of Standard Wooden Trestles for Heavy Loadings, is also a progress report.

Subject (5) Relative Merits of Concrete and Treated Wooden Trestles, will be presented by Mr. Ridgway, Chairman of the Sub-Committee.

Mr. Arthur Ridgway (Denver & Rio Grande Western):—There is not much to report on this subject. We offer no excuse but simply ask you to remember in years gone by the difficulties we have had with the same subject. There was nothing more that could

have been done that we did not attempt to do. About twelve years ago we had a pretty serious time, as you remember, in presenting conclusions, and we had a more serious time in getting them adopted. It seems now that they are just as unsatisfactory, or more so, than they were then. We simply have to report that we have done our best.

Chairman H. Austill:—Mr. President, Mr. Ridgway is entirely too modest in his remarks. He has done a great deal of work on this subject. He has collected a great deal of data and he deserves the thanks of this Association. I am glad to know that this subject is going to be continued under Mr. Ridgway's direction.

Subject (7) is Bearing Power of Wooden Piles, with Recommendation as to Best Methods of Determination. This is a progress report, but since this refers to an article published in Engineering News-Record, I wish to correct the formula given in Engineering News-Record which should be "$P=\frac{CS^2 l}{3}$," instead of "$P=\frac{CS^2}{3}$."

On Subject (8), Best Relationships Between the Energy of Hammer and the Weight or Mass of Pile for Proper Pile Driving, to include Concrete Piles, Mr. Chevalier, the Sub-Committee Chairman, is absent. This is a progress report and the material is submitted as information only but we believe it is well worth while. The Committee has a written discussion on this report from the Service Bureau of the American Wood Preservers' Association, which will be presented so that it may get into the Proceedings, if agreeable.

The President:—If there is no objection, it will be so handled.

DISCUSSION OF REPORT ON BEST RELATIONSHIPS BETWEEN THE ENERGY OF HAMMER AND THE WEIGHT OR MASS OF PILE FOR PROPER PILE DRIVING, TO INCLUDE CONCRETE PILES

It has always been recognized that any method for calculating the bearing power of friction piles which does not take account of the ratio between the weight or mass of the pile and the hammer energy applied in driving it, cannot be entirely correct. While there are other factors in pile driving which, at the present stage of our knowledge of soil mechanics cannot be evaluated, it does appear possible, through practical tests, to add a great deal to what we already know as to the effect of hammer energy when applied to piles of different weights or masses. Hammer energy is the product of weight of the moving part of the hammer, and the distance through which it falls, assuming a drop, or single acting hammer. The limits of velocity as developed from the height of fall are so well-recognized that the above question becomes in reality one involving the ratio of hammer weight to weight of pile. In modern pile driving where large hammer energies are required, it is generally considered that velocities exceeding those developed by falls of about three to four feet are apt to be injurious to the pile; consequently the tendency towards increased weights of hammers and decreased heights of fall has become well-established in recent years.

The Sub-Committee on this subject has already made a number of recommendations relative to the proper ratio between hammer energies and weight of pile, for various conditions of driving, the recommended ratios ranging from one to three for soft to hard driving, respectively. No doubt the Sub-Committee had in mind heavy rather than light types of piles when making these recommendations, although it was stated that the hammer should be as heavy as possible without undue damage to a properly cushioned pile. With average wood piles, for example, it is common to use hammer energies ranging anywhere from five to ten times or more the weight of the pile, and ratios of less than five would, in a great many cases, be quite inadequate. For concrete and other types of heavy piles, it is often difficult if not impossible to secure ratios exceeding 1.5, especially where the piles are over thirty feet in length. With these great disparaties in ratios existing as common practice, and yet reasonably good results obtained in many cases, one is led to believe that it would be very hard to lay down any hard and fast rule for guidance in this respect. Moreover, in view of the fact that the heaviest piles weigh only a fraction of the bearing capacity desired to be developed by them, and that

the hammer energy at the conclusion of driving must be sufficient to overcome this resistance as well as the inertia of the pile, it certainly is essential to take this factor into account.

For the purpose of this discussion it is necessary to define what is meant by the best relationship between the energy of hammer and weight of pile for proper pile driving. In many cases economic considerations would preclude the use of equipment which would give the best results, while in other cases inadequate equipment is frequently used because of convenience and the supposition that any capacity up to twenty times the hammer energy can be developed, depending on the extent to which the driving is continued, as indicated by the Engineering News formula. This supposition is of course erroneous, because account is not taken of the net energy available for useful work in the several cases. In this discussion it is proposed to define best relationship between hammer energy and weight of pile, as that which will give uniform results in bearing capacity when the piles are driven to the same final rate of penetration per final blows of the hammer, in uniform soil.

The following is suggested as a possible avenue of approach to the problem, in which the mass of the pile, its weight and ultimate capacity to be developed, are all taken into account. The proposed formula is shown on the chart attached. It is based on the fundamental theory that hammer energy must be sufficient to overcome developed frictional and point bearing resistance of the pile as it is moved through a certain distance, taken as unity, plus resistance due to the inertia of the pile and other losses incidental to deformation, heat generation, vibration of pile and soil and all other wasteful work done. In developing the formula, therefore, it is first necessary to assume some ultimate capacity to be developed, which is indicated by the symbol C^1. Other resistances accounting for lost energy will be taken as proportional to some power of the mass of the pile, although it is known that such factors as density and elasticity of the pile enter the problem. The total resistance to be overcome then may be represented by the expression

$$\text{Resistance} = C + \text{km}^n$$

It is known that resistance due to mass or inertia of a pile increases very rapidly with its weight, and for our purpose it is assumed that the resistance to driving will vary as the cube of the mass of the pile. The constant of the equation will be assumed to be some factor which takes into account the relative effect of this resistance in the particular case in hand, that is to say, its effect in relation to the capacity to be developed. This may be represented by the ratio of force of gravity to capacity of pile, which then gives the expression

$$\text{Resistance} = C_1 + \frac{g}{C_1} m^3 = \frac{C_1{}^2 \text{-} m^3 g}{C_1} \qquad (1)$$

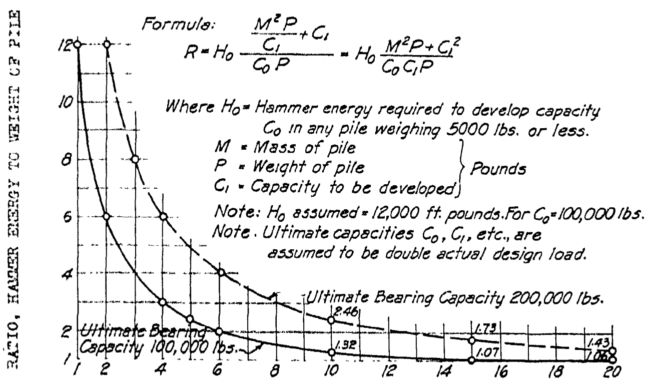
Let us now take three piles weighing 1500, 5,000, and 20,000 pounds respectively, and assume that a bearing capacity of 100,000 pounds is to be developed. This bearing capacity is taken to represent the load that can be carried by the pile without excessive or progressive settlement, usually considered as double the actual load to be used in the design or construction. Carrying out the indicated operations of the equation (1), we have as the total relative resistances to be overcome, the quantities: 100,032, 101,200, and 177,000 for the piles in the order of their weight. The ratios of these quantities are very closely as 1 : 1 : 1.77, which may be taken as the ratios between the hammer energies required to drive the several piles with equal efficiency.

Let us assume that a certain hammer energy H° is required to develop a certain total resistance C° (capacity plus losses) in any pile, then going back to our equation (1) we can write, for hammer energy required

$$H = \frac{H_0}{C_0}\,\frac{C_1{}^2 + gm^3}{C_1} = H_0 . \frac{C_1{}^2 + pm^2}{C_0 C_1} \qquad (2)$$

In the above case where the ratios of total relative resistances are as 1 : 1 : 1.77, let us assume that a hammer energy H^o is required to drive the first pile satisfactorily; then the hammer energy required for the second and third piles would be H° and 1.77 H° respectively, and if it is assumed that H^o is 12,000 foot-pounds, then the hammer energy required to drive the third pile would be 21,300 foot-pounds. The expression (2) above is reduced to one for ratio of hammer energy to weight of pile by dividing by

RATIOS OF HAMMER ENERGY TO WEIGHT OF PILE FOR DEVELOPING STATED BEARING CAPACITY



p, (the weight of pile) which gives the equation shown on the chart. In the case of the third pile above, this ratio would be 1.06 as is plotted on the chart for a pile weighing 20,000 pounds which is to develop a capacity of 100,000 pounds.

The curves of the chart, one for a capacity of 100,000 pounds and the other for 200,000 pounds, are based on a hammer energy of 12,000 foot-pounds required to develop a capacity of 100,000 pounds in any pile weighing up to 5,000 pounds, since in accordance with the above ratios it is seen that the mass of any pile weighing up to that amount would be virtually disregarded, and the total resistance therefore would be the capacity of the pile. The portion of the upper curve to the left of the point representing a pile weighing 7500 pounds is shown by a broken line on the assumption that such large capacities would probably not be feasible to be developed for lighter piles. It is noted the curves conform very closely to an equilateral hyperbola, and this is true because the product of the co-ordinates gives hammer energy, which theoretically should be constant for developing a given bearing capacity. Obviously the curves will depart more and more from the theoretical curve (hyperbola) as weight or mass becomes a more important factor, and it is to be observed that the low point of the curve is approximately reached for a pile weight of about 20,000 pounds. For a pile weighing 40,000 pounds, to develop a capacity of 100,000 pounds, the ratio of hammer energy to weight of pile would rise to 2.15, meaning a hammer energy of 86,000 foot-pounds. This rather leads to the conclusion that it would be impractical to drive piles weighing more than about 25,000 pounds by ordinary methods.

It is interesting to note in Exhibit B the action of the two concrete piles under the second driving after the piles had been allowed to "set" following the loading test. In this driving the same hammer was used for both piles, and the average penetration for the final blows was 1/3 inch for the smaller and 1/5 inch for the larger pile. These piles had previously sustained 61 tons and 94 tons, respectively, and it is assumed that at least this much resistance had to be overcome in moving the piles during the second driving. On this basis the net amount of energy used for moving the piles in the final blows is seen to be approximately 3300 foot-pounds per final blow for each pile, less than one-seventh the gross energy of the hammer. This indicates that about 21,000 foot-pounds of energy was required to overcome resistances due to all causes, before useful work could be done, or considerably in excess of the gross energy of the lighter hammer which was used in the original driving of the lighter pile. Assuming that the penetrations during the second driving were not greater than those given as final, it would be interesting to know what might have happened had the lighter hammer been tried on these piles. If one may judge from the calculated bearing power of these piles at the end of the second driving, their actual capacities were twice or more that at the end of the first driving, and their resistance just before second driving was begun must

have been much greater, since several blows were required to start them. Hence, it is likely that much more than the net energy above calculated was devoted to useful work, and it is quite likely that the lighter hammer might have been able to move one or both of these piles, had it been tried for the second driving.

It is apparent that the test described in Exhibit B falls into the classification of fairly, if not quite, hard driving. This seems evident from the capacities developed in the comparatively short length of piles driven. It also appears that the ratios of hammer energies to weights of piles were adequate, which in this case were 3.41 for the light concrete pile and 2.44 for the heavy one. Had it been necessary for the two concrete piles to be twice as long to develop the same capacities, it is obvious that the driving would have been correspondingly softer, and in such a case the resulting ratios of hammer energy to pile weights, viz., 1.70 and 1.22, would probably still have been adequate. Moreover, since at the end of the first driving the light concrete pile was penetrating at the rate of 3/5 inch per blow, it is apparent that much more capacity could have been secured from this pile with the same hammer, had it been desired to develop the ultimate, and neglecting for the moment the lack of sufficient length to make this possible.

In these tests the average ratio between calculated safe loads and loads actually sustained is about 2.4. Assuming this ratio may be applied to the calculated safe loads developed after the second driving of the two concrete piles, there is obtained the values: 134 tons for the 16-inch pile and 195 tons for the 24-inch pile. It is usual practice to use half the capacity developed by loading tests for the actual bearing values to be used in construction, and this would give 67 tons for the small pile and 98 tons for the large pile. From a standpoint of bearing on the cross-section, the 16-inch pile would be good for a maximum of approximately 65 tons, and the 24-inch pile for about 147 tons. In actual practice the engineer would not think of approaching these maximum values for friction piles, which again indicates that the heavy hammer was not required to develop a proper capacity in the 16-inch pile. However, in the case of the 24-inch pile, where an ultimate bearing capacity of at least 100 tons was probably developed, it appears that the heavier hammer was well adapted to the driving of this pile. This is also approximately indicated by the curves shown on the chart.

It appears reasonable that where piles of the same size and/or weight are driven to the same calculated bearing with different hammers, the test loadings after driving would show more capacity for the piles driven with the heavier hammer. It seems essential to determine what such a difference might be, and it is to be regretted that the test of Exhibit B could not have been arranged to bring out this needed information. In order to have done this it would have been necessary of course to have at least two sets of piles, each pile being driven to the same bearing with different hammers, irrespective of total penetrations secured. The test as made, moreover, adds to the confusion already evident regarding comparative capacities of piles, resulting from numerous previous tests, where piles of the same length but of different types have been driven to the same depth, and then loaded. For example, in this test, the wood pile was driven to a penetration of ¾ inch per final blows, as against 3/5 inch per final blows for the 16-inch concrete pile. Had these piles both been driven to the same final rate of penetration, the calculated capacities would have been the same, and it is likely the wood pile would have actually sustained more load than the concrete pile, since more net energy would have been available for useful work.

Thus in all cases where loading tests are made on piles of different types for the purpose of comparing their bearing capacities, the importance of driving each pile to the same final rate of penetration with the same hammer, or to the same calculated bearing with different hammers, can not be overemphasized. It is inconceivable that the engineering profession has been led into the fallacy of comparing pile efficiencies on the basis of equal total penetrations rather than equal developed resistances in the several piles; yet nearly all tests for comparing capacities have been conducted on such a basis. There is little need to comment on the supposition that a true comparison of several piles can be made when some of the piles are only partly driven, while others are fully driven. In the particular case at hand, the maximum structural capacity of the wood pile was approximately 86 tons, based on bearing on the cross-section, or considerably in excess of that of the 16-inch concrete pile calculated at 65 tons, and in view of this fact, it would have been of great interest to have carried the driving of the wood pile considerably further.

Where, as in the test of Exhibit B, two hammers are available, it would be interesting and profitable to carry out a test with three sets of piles, the piles of each set being

similar to those of Exhibit B, except for length which should be worked out to accommodate the details of such a test. The first set would be driven with the lighter hammer, all to the same final rate of penetration. The second set would be driven with the heavier hammer, each pile to the same calculated bearing as in the first set. The third set would be driven with the heavier hammer to the same final rate of penetration per blow, as in the first set with the lighter hammer. To secure still further information, each of the first two sets could receive a second driving after the loading test and a period of "set," the heavier hammer being used, and driving first, to the same calculated bearing, and finally to the same rate of penetration per blow, providing this might be possible after the piles had set. In securing facts for the working out of a problem of this kind, it is essential to work from data that are comparable in every respect, and because of the interest and importance of this subject, it is sincerely hoped that further tests, along the lines noted above, may be undertaken. Meanwhile it should be stated that the test as made by the Missouri Pacific Railroad and reported in Exhibit B is a most important and valuable contribution to this subject, and one for which the Association and every interested engineer is no doubt indebted to this Company.

Chairman H. Austill:—Subject (9), Improved Design of Timber Structures to Give Longer Life with Lower Cost of Maintenance, is a progress report.

Subject (10), Improved Methods of Strengthening Existing Bridges, will be presented by Mr. Grear, Chairman of the Sub-Committee.

Mr. S. F. Grear (Illinois Central):—The report is printed as Appendix I, pages 73 and 74. The Committee has collected data on the strengthening of timber bridges from its own members and the report is published as information with the thought of bringing out discussion and suggestions from the members of the Association.

We should like to read just the first paragraph of the report: "In preparing this report, it is assumed that the intent is to outline methods of changing structures to a heavier type and not to cover ordinary repairs. This will cover only wooden trestles."

The report is submitted as information and progress.

Chairman H. Austill:—On Subject (11), Design of Washers, Separators, Cap-Stringer Straps and Other Trestle Fastenings, the Committee reports progress, but I should like to call attention to a bulletin on Modern Connectors for Timber Construction by the National Committee on Wood Utilization, which can be obtained from the Superintendent of Documents for 15 cents, and which is very closely related to this assignment and contains considerable information of much value. Mr. President, that concludes the report of this Committee.

The President:—Are there any questions or remarks? In connection with what was mentioned in regard to Mr. Ridgway, the Board of Direction yesterday appointed a Coordinating Committee, on which are two members of the Committee on Wooden Bridges and Trestles, the Steel Structures Committee and the Committee on Wood Preservation. Mr. Ridgway will be the Chairman of that special Committee. This is a coincidence because it brings out a thought I had in my address a few minutes ago—the idea of coordinating and working out those factors in regard to economical construction to take care of the progress on individual lines where traffic and other conditions are changing.

If there are no questions to be asked of this Committee, they are excused with the thanks of the Association (Applause).

DISCUSSION ON IRON AND STEEL STRUCTURES

(For Report. see pp. 285-308)

Mr. A. R. Wilson (Pennsylvania):—This Committee's report is found in Bulletin 351, page 285, the first report in the Bulletin.

Your Committee respectfully presents herewith report covering the following subjects:

(2). Track Anchorage Over Bridges and Similar Structures. I shall ask Mr. Lacher, Chairman of this Sub-Committee, to make the report.

Mr. W. S. Lacher (Railway Age):—The study of any subject for the purpose of formulating rules of good practice should begin with determination of facts, but in the study of creepage of track, either on structures or on roadway, the facts available are confined to the observations of Engineers and to the rules of practice that they have developed as the result of those observations. Little, almost nothing, in fact, is known concerning the forces that are responsible for the creeping of track, and, in the opinion of the Committee, it is doubtful if research for the purpose of developing reliable data on the forces which cause creeping of track can be justified.

In these circumstances, the Committee was forced to confine its study to such information as it could obtain from Engineers who have made a study of creeping and anchorage and endeavor to formulate rules based on such experience. This was not an easy thing to do because it was necessary to attempt to reconcile some widely diversified opinions. The Committee feels, however, that the rules as given on page 287 of this report cover practically all ordinary conditions that would be encountered. The rules are rather long.

The Conclusions are as follows:

"1. Bridges are designed to resist only such longitudinal forces as are imposed within the length of the structure. The magnitude of the forces that cause rails to creep is unknown and may be transmitted from rail to rail for appreciable distances. Consequently the anchoring of rail on a bridge may impose longitudinal forces to the structure for which no adequate provision has been made in the design."

The President:—Are there any questions or is there any discussion on the first? If not, proceed.

Mr. W. S. Lacher:—"2. The first step in overcoming the creeping of rails on a bridge is to anchor the rails effectively on the adjacent embankment."

The President:—We will take each one separately and see if there is any question or discussion on it. We will have a short pause following each one. Is there any discussion on this one?

Mr. W. S. Lacher:—"3. With adequate anchorage of rails on the adjacent embankment there should be no need for any anchorage of rails on short bridges.

"4. If rails on a bridge creep in spite of effective anchoring of the rails on the adjacent embankments, the anchoring of the rails to the bridge will prove satisfactory and effective in many cases, but such anchoring must be undertaken only when the movement of rails on the bridge is not the result of uncontrolled creeping on the adjacent embankments.

"5. If inability to control excessive creeping of the rails on the adjacent embankments produces objectionable movement of rails on the bridge, it may be necessary to introduce adequately guarded switch points at each end of the bridge, anchoring the rails on the bridge if necessary, and allowing the rail on the adjacent embankments to run."

The President:—Is there any discussion on that?

Mr. L. B. Allen (Chesapeake & Ohio):—Why call it embankment? It may be on a cut and not on an embankment. Why not say "on the adjacent track"? The bridge does not always have an embankment at the end of it.

Mr. W. S. Lacher:—We could use the word "roadbed." Would that cover it?

The President:—That is better.

Mr. W. S. Lacher:—I take it that that would apply to the use of that term all through the report.

The President:—Would you take note of that matter? I am glad Mr. Allen brought that question up.

Mr. C. W. Baldridge (Santa Fe):—It appears to me that the last half of that sentence, "and allowing the rail on the adjacent embankments to run," might better be changed to read, "to guard against the effect of creeping of rail on the adjoining track."

It isn't necessary to place anything in here permitting the rail to run. It should not be allowed anywhere. It would be more appropriate to say that the switch points are placed to guard against the creeping of rail on adjacent track.

Mr. W. S. Lacher:—Well, paragraph 5 takes care of the case where the movement of rail on the bridge is under control or can be controlled effectively and where there has been difficulty due to the movement of rail on the embankment, as in the case of a bridge in a sag. The use of the expression "allowing the rail on the adjacent embankments to run" seems to be the only way to express the condition that had to be met and the reason the switch points ought to be put in.

Mr. C. W. Baldridge:—I move that the words "and allowing the rail on the adjacent embankment to run" be stricken out and that we substitute the words, "to guard against the effect of creeping rail on adjoining track."

The President:—Mr. Baldridge, in order that we can all understand it, will you please read in full what it is you propose?

Mr. C. W. Baldridge:—Paragraph 5 would then read:

"5. If inability to control excessive creeping of the rails on the adjacent embankments produces objectionable movement of the rails on the bridge, it may be necessary to introduce adequately guarded switch points at each end of the bridge, to guard against the effect of creeping rail on the adjoining track, then anchoring the rails on the bridge if necessary."

Mr. W. S. Lacher:—The sense of that may be all right, but the way it has been put would very easily give a wrong impression,—"anchoring the rails on the bridge if necessary."

Mr. C. W. Baldridge:—It would be more appropriate, perhaps, to rewrite the entire article and introduce "to guard against the effect of creeping rail on adjacent track" ahead of the provision for placing switch points in the track at the ends of the bridge.

Mr. W. S. Lacher:—That can be done. It will take some rewording to carry it out.

The President:—What disposition do you want to make of your motion, Mr. Baldridge?

Mr. C. W. Baldridge:—If the Committee care to reword that, I would withdraw my motion.

Mr. W. S. Lacher:—The Committee will do that.

"6. If inability to control excessive creeping of rails on the bridge, in spite of effective anchorage of the rails on the adjacent embankments, produces objectionable movement of the rails on the bridge, it may be necessary to introduce adequately guarded switch points at each end of the bridge and allow the rails on the bridge to run." That introduces the same clause to which Mr. Baldridge made objection, and, if the convention will permit, the Committee will consider the elimination of that.

The President:—And No. 6 would be covered by the rearrangement of No. 5?

Mr. W. S. Lacher:—Yes, sir.

The President:—If there is no objection, we will take the Committee's recommendation on that. That part of paragraph 6 will be eliminated?

Mr. W. S. Lacher:—No. 6 will be modified to agree with No. 5.

"7. In these cases where the rails are anchored on the bridges: "(a) Commercial rail anchors of demonstrated effectiveness on roadway track will generally be found effective on bridges."

The President:—What is meant by "commercial rail anchors"?

Mr. W. S. Lacher:—A rail anchor that is on the market.

Mr. G. S. Fanning (Erie):—I move that we strike out the word "commercial."

Mr. W. S. Lacher:—The Committee will withdraw that word.

"(b) Rail anchors should be applied to ties that are effectively secured against longitudinal movement relative to the bridge members on which they are supported.

"(c) Anchors applied to rails on a bridge should be so located relative to the expansion bearings of the spans, or slip joint as to permit the proper movement of the rails relative to the structure.

"(d) The number of anchors applied and their distribution along the structure will depend on the severity of the creeping action, its direction, and whether or not it is necessary to resist movement in more than one direction."

Mr. President, I move the adoption of these Conclusions, subject to the revisions requested from the floor.

The President:—You have heard the motion and the second. Is there any more discussion? Are there any more remarks?

(The motion was put to a vote and carried.)

Chairman A. R. Wilson:—Subject (3), Fusion Welding and Gas Cutting for Steel Structures. I shall ask Mr. Reichmann, Chairman of this Sub-Committee, to present the report.

Mr. Albert Reichmann (American Bridge Company):—In preparing this specification for presentation to the Association, we followed what is considered the best present day practice in welding. As the specification is rather elaborate, I do not think anything would be gained by reading it here. Since the art of welding has not been generally applied to bridge work, it is hoped that the members of the Association who have studied and applied it will give us the benefit of their experience.

The President:—Mr. Reichmann, you have a very fine report here and I hope that the members will abide by what you say. It is a very interesting and very live subject. I believe a great many of the bridgemen were very much opposed a few years ago to the electric welding for bridge erection, assemblying or their strengthening. There might be one or two matters that you want to question Mr. Reichmann about. I think he is very well qualified to answer any questions you may ask him on this subject.

Mr. Albert Reichmann:—The Committee should like to receive any criticisms or recommendations that members care to make, and we shall be glad to give these our consideration during the coming year.

Mr. B. R. Leffler (New York Central):—I wish to add that these specifications (I think Mr. Reichmann will agree with me; if not, I hope he will say so) are not intended to cover or be a universal substitute for the riveted joint. This is a field of welding which is very serviceable in bridge work, particularly in repairing existing structures. There is nothing in these specifications that signifies that the welding art is g ing to supersede all riveted or pin-connected work, and riveted work in particular. I mention that because it is a fact that Bridge Engineers have been opposed to it. I am one of them. I am still opposed to it as a universal process for getting rid of every difficulty. It has its field.

The President:—I am glad, Mr. Leffler, that you brought that out. That is what I am trying to get from the audience—the ideas and opinions they may have on these subjects.

I do not believe it is the thought or idea that electric welding will supersede all riveted or pin-connected construction work. I think there is a place for everything and everything has its place.

Mr. Albert Reichmann:—I thoroughly agree.

Chairman A. R. Wilson:—The report on Subject (12), Repainting of Steel Bridges, with Special Reference to the Condition Requiring Repainting and Economical Method of Doing the Work, is shown as Appendix C. I shall ask Mr. VanNess to make the report.

Mr. R. A. VanNess (Santa Fe):—The Chairman of this Sub-Committee, Mr. Stuart, is not able to be here today. Mr. Stuart has spent a lot of time, about two years, in preparing this report. He has received information from various members of Committee XV as a whole, and he has combined the results of his study with what the Committee gave him in the Conclusions on page 299. I will read those Conclusions rapidly:

"1. It is better practice and more economical to do spot painting or complete repainting during the incipient stages of corrosion, rather than defer such work until corrosion has reached an advanced stage.

"2. It is important that the surfaces to be repainted be thoroughly clean and dry, and that the weather and atmospheric conditions be favorable.

"3. Only paints of good quality, thoroughly mixed, should be used.

"4. On small jobs, it is preferable to employ company forces. In the case of large projects, contract work, under close supervision, may be more economical.

"5. Paint gangs should be composed of men of experience, and be well equipped with all necessary apparatus."

Mr. Chairman, I make a motion that these Conclusions be received as information.

The President:—If there is no objection, the report will be so received.

Chairman A. R. Wilson:—The report on Subject "(13), Bronzes for Various Purposes in Connection with Iron and Steel Structures," is found in Appendix D. It seems that this entire Sub-Committee, with the exception of Mr. VanNess, is absent. As this report is to be received as information only, I will call attention to the object of the investigation.

"The object of this investigation was to determine the coefficient of friction between various combinations of bronzes and steels."

This report furnishes valuable information for designers in connection with expansion bearings where flat surfaces are used.

The President:—Are there any questions that you want to ask this Committee?

Mr. J. C. Irwin (Boston & Albany):—I should like to ask Mr. Wilson if this completes his assignment on this subject.

Chairman A. R. Wilson:—It does not, Mr. Irwin, complete it. Our assignment covers uses of bronzes for structural purposes. This may not be the proper wording of the assignment. This does not conclude the subject.

Mr. J. C. Irwin:—Is not that the same case on Subject (12)? Did you conclude that report with the adoption of the conclusions?

Chairman A. R. Wilson:—No, sir. We have not recommended adoption of the conclusions on repainting of steel bridges. Neither of these subjects are concluded.

Mr. J. C. Irwin:—I have one other question. On the subjects on which no report has been made, are we to consider that you report progress?

Chairman A. R. Wilson:—Yes, sir. There seems to be confusion as to how the

committees are to report. This Committee has followed the practice of not reporting progress on subjects where there is no report to be made, reporting only where there is definite information to be presented to the convention. This may be an error in so making our report. The other subjects are all being actively studied on which we can report progress.

Mr. J. C. Irwin:—I think that will clear the situation. The Committee on Outline of Work will cover those subjects by reassignment during the year, but it seems to me that it would be good practice to say in the report, for the benefit of the members, that progress is being made on these subjects on which no further report is made.

The President:—Are there any other questions you want to ask this Committee?

This is another Committee that coordinates with a lot of fellows around Washington, and especially on grade crossing work. They are doing excellent work and, with this Coordinating Committee that I mentioned a little while ago, we are going to produce some very valuable information for the railroads of the country as a whole. If there are no more questions that you want to ask this Committee, they will be excused with the thanks of the Association (Applause).

DISCUSSION ON CLEARANCES

(For Report, see pp. 261–262)

(Vice-President W. P. Wiltsee in the Chair.)

Mr. A. R. Wilson (Pennsylvania):—The report of this Committee is found in Bulletin 350, page 261. It covers the submission as information of two diagrams. One is the outline of proposed A.R.A. box car, shown in Fig. 6; the second one a Clearance Diagram for Pantograph, as shown in Fig. 7.

The clearance diagram for pantograph, as shown by Fig. 7, is for car on tangent track and includes an amount due to sway of car. On curved track the clearance shall be increased, due to superelevation of rail.

The action recommended is that these diagrams, Fig. 6 and 7, be received as information.

Vice-President W. P. Wiltsee:—Is there any discussion on the subject? This is a very important matter and I am sure the Committee would like to have some discussion on this subject.

Chairman A. R. Wilson:—The diagram of the car is the product of the Car Construction Committee of the Mechanical Division.

Vice-President W. P. Wiltsee:—If there is no discussion on the subject it will be received as information.

Chairman A. R. Wilson:—I should like to state for the benefit of the Yards and Terminals Committee and the Buildings Committee, in connection with the clearance or height of platforms, that last year the Clearance Committee presented a report, it being adopted, fixing the height of platforms for freight houses. Since that report has been made, which indicated a height of platform of 4 feet, the Car Construction Committee of the Mechanical Division submitted a report covered in Circular DV–768, describing a steel-sheathed, wood-lined box car. The height of the floor of that car is 3 feet and 7 and ¾ inches. I am calling this to the attention of the respective Committees as it may affect somewhat their studies during the coming year. The Clearance Committee will also note and be governed accordingly.

That concludes the report, Mr. President.

Vice-President W. P. Wiltsee:—Is there any further discussion? Is there any discussion on the pantograph clearance? If not, the Committee will be dismissed with the thanks of the Association (Applause).

DISCUSSION ON ELECTRICITY

(For Report, see Bulletin 348)

(Vice-President W. P. Wiltsee in the Chair.)

Mr. W. M. Vandersluis (Illinois Central):—In lieu of a formal report by your Committee on Electricity, to save duplication in printing, we offer as information a series of reports presented to the Electrical Section in October last. These reports are printed in full in Bulletin 348 of August, 1932.

Briefly summarized, the report covers the following subjects:

Inductive Coordination.—Cooperation has been continued with the National Electric Light Association and with the Bell System in the preparation of a code of "Principles and Practices for the Inductive Coordination of Railway Electrical Supply Facilities and the Communication Facilities of the Bell System."

Power Supply.—The progress of electrical "Power Supply" in the United States, Canada and Mexico, and, to a lesser extent in Europe, is reported on.

Electrolysis.—A comprehensive report is made on electrolysis resulting from leakage of current from the catenary and third rail systems over the supporting insulators. The experience of the Chicago, Milwaukee, St. Paul & Pacific, the Illinois Central, the Cleveland Union Terminals Company, and the Delaware, Lackawanna & Western, is covered in the report.

Overhead Transmission Line and Catenary Construction.—Specifications for round and grooved hard drawn copper trolley wire and for round and grooved bronze trolley wire are presented.

Economics of Railway Location as Affected by Electric Operation.—A summary is given of a study made on this subject in past years by the Construction and Maintenance Section.

Standardization of Insulating Tapes.—Revision of specifications for friction tape to replace the present form is presented.

Standardization of Insulators.—Progress in this subject is reported pending the formulation of specifications for porcelain insulators for electric power lines by a Sectional Committee of the American Standards Association.

Protection of Tracks Used in the Loading or Unloading of Inflammable Liquids from Danger of Fire Caused by Electric Sparks.—The report on this subject covers rules for the handling of gasoline on rail cars, railway coaches and trucks.

Specifications for Track and Third Rail Bonds.—This report will be of special interest to the Construction and Maintenance Section. It covers detail bond design, rail joint clearance and its effect on rail bond design, including experience with various types of bonds.

Illumination.—A comprehensive report is made on this subject, including a schedule of incandescent lamps, railway floodlighting systems and train lighting lamps.

Design of Indoor and Outdoor Substations.—A most interesting and valuable report is given under this heading, grouped under the following sub-divisions: Substation Protection; Outdoor Type Frequency Changer Sets Used in Connection with Railroad Electrification; and Recent Developments in Mercury Arc Rectifiers for Railroad Substations.

Application of Corrosion-Resisting Material to Railroad Electrical Construction.—This is another report that should be of special interest to the Maintenance Engineer. It is a record of tests made on the Norfolk & Western and the New Haven roads, on samples installed in smoke jacks, tunnels, and in salt water atmosphere.

At your last meeting a recommendation was made that reference be made in your Manual to the approved material contained in the Electrical Section's Manual and that this reference be kept up to date by adding current approved matters. This recommendation has been favorably acted upon and the result is shown in the Supplement to your Manual, Bulletin 347 of July, 1932.

I would suggest that this report be accepted as information, Mr. President.

Vice-President W. P. Wiltsee:—This is a very valuable report from the Electrical Section. It is submitted to this Association by the Electrical Section as information. I am sure they would be glad to have any questions asked or any discussion on the subject. If there is no discussion and no objection, the report will be so received. The Committee is dismissed with the thanks of the Association (Applause).

DISCUSSION ON SIGNALS AND INTERLOCKING

(For Report, see pp. 263–272)

(Vice-President W. P. Wiltsee in the Chair.)

Mr. P. M. Gault (Missouri Pacific):—The report of this Committee will be found in Bulletin 350, beginning with page 263. Of the eight assignments the Committee had, reports are submitted on six, (3) and (6) being merely collaboration with other Committees.

Assignment (1), Revision of Manual, will be found in Appendix A, at the top of page 264. I believe it is unnecessary to read this report and I would move that it be approved.

Vice-President W. P. Wiltsee:—It has been moved that the report of the Sub-Committee on Revision of Manual be approved. In order that everyone may understand what that means, we will ask the Chairman to read the recommendations.

Chairman P. M. Gault:—"Your Committee recommends the voiding of all Signal Section matters now in the A.R.E.A. Manual and Supplements, and the printing in the next Supplement to the Manual of a complete index to the Signal Section Manual as furnished by the Secretary of the Signal Section."

That is to say, the index will be as of the date it is printed.

"Your Committee further recommends that notice of changes only be made each year in future Supplements to the A.R.E.A. Manual and that the complete current index be printed only when the A.R.E.A. Manual as a whole is revised."

Vice-President W. P. Wiltsee:—The Board of Direction will take the proper action on this recommendation.

Chairman P. M. Gault:—The next assignment is (2), Developments of Automatic Train Control. This report is offered as information. I should like to state that on page 265, near the bottom of the page, five railroads are shown as having filed petitions for relief from maintaining automatic train control. Since this report was printed, the C. B. & Q., the Texas & New Orleans, the Missouri Pacific, and the C. R. I. & P. (second order only) have had the orders affecting them suspended. The decision has not been announced for the Delaware & Hudson, so far as I know. This report is offered as information.

Vice-President W. P. Wiltsee:—If there is no objection, we will so receive it.

Chairman P. M. Gault:—The next report is on (4), Increased Efficiency Secured in Railway Operation by Signal Indications in Lieu of Train Orders and Timetable Superiorities. I will ask Mr. Post, Chairman of the Sub-Committee, to handle this report.

Mr. W. M. Post (Pennsylvania):—This report is found on page 266. It relates to the economic results on the Omaha Division of the Missouri Pacific Railroad. The Omaha Division is a single-track line about 400 miles in length, and on that line, between Kansas City and Atchison, is a bottleneck of about 47 miles. Over that bottleneck, besides the Missouri Pacific trains, move trains of the Chicago Great Western and the Union Pacific. I understand that in the year 1931 in this bottleneck there were about 50 trains moving daily. Measured in net ton miles per mile of road, between Leavenworth and Atchison, 20 miles, the traffic density would be 4,456,000, and between Kansas City and Leavenworth, 23 miles, 6,371,000. On the balance of the Division, measured by the same yardstick, there would be 1,436,000, which I think is about 12 to 15 trains a day.

On this 47 miles centralized traffic control was installed in order to relieve the delays and congestion and also to save money. This report gives some of the economic results.

In Table I on page 267 you will notice that the saving in freight train cost on the part of the Division not including the centralized traffic control section was $205 per mile per year, and in the centralized traffic control section it was $1,524 per mile per year.

In the centralized traffic control section there was an additional saving in block and interlocking stations discontinued of $642, making a total saving of $2,166 per mile, from which is deducted the additional expense and interest charges of $693, leaving a net saving of $1,473 per mile, 1930 over 1929, or, for the whole section, a saving of $63,-349.

On the next page you will notice there is a comparison of the freight train performance and costs of the Omaha Division with the centralized traffic control section. That should be shown in Table II. Table II is missing. I have been assured by the Secretary that the table will appear in the Proceedings.

The significant figures are the averages. The averages for the C.T.C. section show a greater percentage of improvement than the averages for the Omaha Division. For example, on the Omaha Division the cost per 1000 gross ton miles is decreased 12 per cent, whereas on the C.T.C. section it is decreased 39 per cent. This is accounted for by the increase in the gross ton miles per train hour on the Division of only 8 per cent, as against an increase on the C.T.C. section of 57 per cent.

The improvement in the freight train performance of the Omaha Division, 1930 over 1929, effected a total saving of $138,781, reducing freight train costs by 12 per cent. Of this saving, 47 per cent is due to the improvement in train operation through the C.T.C. section, and as there was no increase in the locomotive tractive effort full credit should be given to the C.T.C. installation for the increased efficiency in operation secured through the use of signal indications in lieu of train orders and timetable superiorities. Some 50,-000 train orders per year were eliminated.

Summary of the C.T.C. section: The gross tons per train increased 6 per cent; train miles per train hour (speed) increased 47 per cent; gross ton miles per train hour increased 57 per cent; cost per 1000 gross ton miles decreased 39 per cent; locomotive tractive effort 72,300 pounds, no change; net return on total investment, 14.7 per cent.

This report is submitted as information.

Vice-President W. P. Wiltsee:—While this report is submitted as information and it will be so received, I am sure that the Committee would like to have some discussion on the subject. It is a very important matter, one of the most important subjects we have before the railroads today in the matter of economy.

Chairman P. M. Gault:—I will ask Mr. Stradling, Chairman of the Sub-Committee which handled the subject, to report on Current Activities of the Signal Section.

Mr. E. G. Stradling (Chicago, Indianapolis & Louisville):—This report is found on page 269. It shows the current activities of the Signal Section since March of last year up to November, 1932. On the same page is found the specifications of the Signal Section, as revised. At the bottom of the page are shown new specifications adopted by the Signal Section. On page 270 are shown the revised requisites of the Signal Section, specifications to be removed from the Manual of the Signal Section, and requisites to be removed from the Manual of the Signal Section. This report is submitted as information.

Vice-President W. P. Wiltsee:—Are there any objections? If not, it will be so received.

Chairman P. M. Gault:—The next subject is (7), Possibility of Providing Suitable Protection at Less Cost than the Present-Day Practice for Both Construction and Maintenance of Signals and Interlocking. I hope there will be some discussion of this subject. I am going to ask Mr. Wiegand, Chairman of the Sub-Committee, to handle it.

Mr. F. B. Wiegand (New York Central):—The report is divided into various sections: Historical, State Requirements, Recommended Practice, Construction Cost, Maintenance Cost, and the Summary.

In this presentation I shall refer only to the Summary and comment thereon.

The recommendations of your Committee are as follows:

"To Lower Cost of Construction: Determine minimum requirements and have all interested departments approve the plan of the track layout."

This is an important item as any change upsets all calculations and involves changes in bill of material, delay and additional expense for interlocking machines on account of change in locking and change in circuit controller arrangement and their application. Where duct lines are used the number of ducts are involved as the number of wires of their size (in order to provide proper carrying capacity) may be increased, either of which will increase the outside diameter of the cable and may involve additional cables or ducts. It at least involves change in the makeup of the cable.

"Adopt universal switch layout."

Some roads are now doing this. It reduces considerably the cost of interlocking, as all ties, tie plates, rail braces and other switch fittings are not disturbed or replaced when interlocked.

"Standardize signaling material."

Considerable has been done along this line. It enables the manufacturer to reduce his variety of stock and sell at a lower price.

"Use power tools where practicable."

This item reduces labor cost; very often one man can do the work of two or three men. We have in mind such tools as rail-bonding machines, power drilling machines at site of the work, paint spraying machines, small concrete mixers, etc.

"Use unskilled labor for unskilled work."

In the construction of an interlocking plant there is a vast amount of work commonly classed as laborers' work, such as digging, refilling, handling material, assisting in erecting poles, etc., which should be done by laborers and not by the signal craft who receive a much higher rate of pay.

"Use modern materials."

As materials are developed which may be lower in price or less expensive to install, but at the same time answer the purpose fully as well as materials generally used, these should be considered.

"Use of apparatus of lower standard of excellence where safety is not involved."

By lower standard of excellence we do not mean materials that do not have lasting qualities nor materials that fail frequently to operate as intended. We do mean less expensive materials which will answer the purpose satisfactorily, but with less rigid specifications.

"Omit Derails."

Derails are non-essentials. In multiple track territory they are a source of danger. It may have been all right to use these in earlier days when signals were few and far between, but today when enginemen run by signal indications, and must keep constantly alert, their use is but an added expense.

"To Lower Cost of Maintenance:—"Build soundly and solidly."

By this is meant that signaling should be installed in a substantial manner; in other words, installed to stay and not installed to stay only when kept there by the maintenance forces.

"Employ ample supervision."

By ample supervision is meant sufficient supervision to see that the maintenance force is performing a day's work for a day's pay.

"Reclaim materials that may be reclaimed at less cost than new."

This item is self-explanatory. It is an important one. Large quantities of expensive materials are involved.

"Omit reports where practicable."

The omission of non-essential reports will give the maintenance force more time to devote to maintenance and will permit reduction in their numbers or extension of their territory.

"Omit derails."

If omitted they need not be maintained, and as they are not essential for train movements, their omission seems desirable.

The report is submitted as information, Mr. Chairman.

Vice-President W. P. Wiltsee:—While the report will be so received unless there is some objection, I am quite sure that the Committee would like to have some discussion on the subject. This is a very important matter. The Committee has submitted an excellent report and I trust that there will be some questions asked or that there will be some discussion of the subject.

Mr. C. A. Taylor (Chesapeake & Ohio):—I should like ask the Committee if they can in any way modify or amplify No. 7, under "To Lower Cost of Construction," where it reads: "Use apparatus of lower standard of excellence where safety is not involved." Just what did they have in mind there?

Mr. F. B. Wiegand:—One particular item I have in mind is a relay on an interlocking machine used for indicating purposes, that is, it is used for giving a visual indication of some kind. In other words, apparatus similar to that now in use on CTC interlocking machines.

Mr. C. A. Taylor:—You do not have in mind using the cheap material?

Mr. F. B. Wiegland:—No, not at all. Quality is essential.

Mr. J. C. Irwin (Boston & Albany):—These recommendations are most helpful. I just want to clear up one point and that is on the recommendation on the elimination of derails, whether it means at all points, that is, at railway crossings at grade, and also on the minor tracks connecting the main tracks. The recommendation seems to be a little general and I should like to have that cleared up.

Chairman P. M. Gault:—The Signal Section's recommended practice on derails is: "Derails should not be used in main tracks. On heavy grades, where the need of

some device to check runaway trains or cars is indicated, properly designed deflecting tracks may be used."

That is quoted from the top of page 271 of the report.

The report on Use of Flashing Lights in Railway Signals is found on page 272. The Chairman of that Sub-Committee is not present, so I shall endeavor to report for him. The Committee has understood this assignment to refer to signals other than highway crossing protection signals. Flashing lights are almost universally used for that purpose.

Your Committee has canvassed a selected list of thirty railways from which twenty-seven replies were received. Only three railways advise that they are now using flashing lights to govern or control the movement or operation of trains.

The word "three" should be corrected to read "four," as one railroad was added after this was first written. The Missouri Pacific, Pennsylvania, Southern Pacific and the Michigan Central Railroads are using flashing lights for other purposes than highway crossing protection.

The conclusion reached by the Committee is "that the restricted use of flashing signals under special rules or instructions is permissible at selected points."

This report is offered as information.

Vice-President W. P. Wiltsee:—This report will be so received as information unless there is objection thereto. Is there any discussion on the subject?

Chairman P. M. Gault:—This concludes the report of your Committee.

Vice-President W. P. Wiltsee:—The Committee will be dismissed with the thanks of the Association in the light of information they have presented (Applause).

DISCUSSION ON YARDS AND TERMINALS

(For Report, see pp. 167–207)

Mr. M. J. J. Harrison (Pennsylvania):—The report of the Yards and Terminals Committee will be found on pages 167 to 207 inclusive, of Bulletin 350. The subjects assigned to the Committee and the action recommended on the reports are detailed on page 167.

Subject (1) is Revision of Manual. Unless there be objection, the three sections of proposed new or revised Manual material will be submitted by the respective Sub-Committee Chairmen as they report.

Subject (2) is that of Produce Terminals. The report will be presented by Mr. E. T. Johnston, Chairman of the Sub-Committee.

Mr. E. T. Johnston (Erie):—Last year this Committee submitted a report on this subject as information. The report has been reviewed and condensed and the material appearing in Bulletin 350, pages 173 to 175 inclusive, is submitted with a recommendation that it be adapted for inclusion in the Manual. I will read the section headings: General Type, Buildings, Track Layout, Driveways, Platforms, Icing, Garbage and Refuse Disposal, Miscellaneous.

I move this material be adopted for inclusion in the Manual.

Vice-Chairman M. J. J. Harrison:—I second the motion.

The President:—It has been moved and seconded that this material be included in the Manual. Is there any discussion?

Mr. A. R. Wilson (Pennsylvania):—Under Platforms, I called the attention of the Committee this morning to the standard box car height of floor, as being 3 feet 7 and ¾ inches above top of rail. I also understand that the house platforms, under para-

graph 30, covers refrigerator cars only. I am wondering what attitude the Committee will have on this new box car proposed by the Mechanical Division. I am serving on a committee with the Terminal Engineers of the City of New York where we were endeavoring to arrive at a height of platform to serve both cars and automobile trucks. We have been confronted with the 4-foot height of platform as being the average height, and the box car proposed, the floor of which is lower.

Mr. E. T. Johnston:—I assume this is more general. This paragraph 30 refers to refrigerator cars, of which I believe the floor height is approximately 4 feet.

Mr. A. R. Wilson:—This dimension agrees with the Clearance Committee's recommendation now in the Manual?

Mr. E. T. Johnston (Erie):—Yes.

The President:—Mr. Wilson, in that same connection, as I understand it, you are not satisfied with the dimension shown in paragraph 28. Is that right?

Mr. A. R. Wilson:—It is paragraph 30 I question, Mr. President, the 4-foot height. I say that agrees with what is now in the Manual for the refrigerator cars. I am wondering what attitude the Committee may have on this new A.R.A. box car.

Mr. E. T. Johnston:—This is intended to refer, naturally, to contacts for refrigerator cars only.

The President:—What height of floor is there on the new A.R.A. car?

Mr. A. R. Wilson:—It is 3 feet, 7 and ¾ inches.

The President:—That is the test car, the one the Pennsylvania now has on trial?

Mr. A. R. Wilson:—Yes, sir. The heading reads "Design of Steel-Sheathed Box Car." It is to be used in interchange service. It is dated June, 1932, and issued by the Mechanical Division of the American Railway Association.

Mr. E. T. Johnston:—I do not see that that is exactly applicable to this situation, Mr. Wilson, where we are figuring on refrigerator cars.

Vice-Chairman M. J. J. Harrison:—Is not the answer to Mr. Wilson's point that the Yards and Terminals Committee can and will take cognizance of the situation that he mentions in future study of freight house platforms and similar facilities? In so far as Produce Yard platforms are concerned, the Yards and Terminals Committee feels that the recommendations as submitted in the report here under consideration are proper and correct.

The President:—Is there further discussion?

(The motion was put to a vote and carried.)

Mr. E. T. Johnston:—On page 176 of the same Bulletin there is a condensed summary of data obtained from questionnaire circulated in 1931. It is submitted as information and I move that it be received as such.

Mr. W. A. Radspinner (Chesapeake & Ohio):—Reference is made here to special features: "Special features should be considered, such as heating, refrigeration, air conditioning, ripening rooms and special requirements of the dealers." The location of these ripening rooms may have quite an effect on the insurance of the whole property. As a rule, these rooms are equipped with facilities for using ethylene, a compressed gas. This gas is flammable and burns in air when the proportion of ethylene to air is between 3 and 34 per cent. When mixed with air in these proportions an ignition by electric spark, flame or heated surface will result in an explosion. The location of such a hazardous operation and the storage of the compressed gas cylinders should be installed and operated according to the recommended safeguards for the coloring of fruits and vegetables issued by the National Board of Fire Underwriters.

The President:—Is there any more discussion? This part of the report, as you know, is submitted as information only. The last speaker possibly overlooked the fact that we have passed on the point that he has brought out.

Do you want that matter reopened or shall we just let it go? If there is no objection, we shall let it go, as it was voted on before. Page 176 is accepted as information.

Vice-Chairman M. J. J. Harrison:—Subject (6), as assigned to the Yards and Terminals Committee, is Hump Yards. This report, including proposed Manual material, will be presented by Mr. E. M. Hastings, Chairman of the Sub-Committee.

Mr. E. M. Hastings (Richmond, Fredericksburg & Potomac):—On page 168 this material is offered this year for the Manual. It is entitled Hump Yard with Retarders. It has been before us for sometime, was reported on at least last year as information, and has been boiled down now to something that is really workable and is in such condensed form that we are offering it for the Manual, and I will so move.

(The motion was put to a vote and carried.)

Mr. E. M. Hastings:—We now turn to page 177, running through to page 189, where you will find the report of the Sub-Committee for this year, which is really completing work that has already been before you in reports of previous years, particularly the report of last year. We are coming down now to more concrete examples and we are presenting this year two studies of what might be termed the Graphic Methods that may be used in designing hump yard gradients for use in connection with the application of car retarders. These methods are Graphic Method "A", which is an application or a presentation of the method to a yard which was shown as Fig. 1 in last year's report, and Graphic Method "B", the application of a method to a different yard, composed of some 50 tracks, such as shown as Fig. 5 in this year's report.

Since the publication of this Bulletin we have received some very interesting written discussion, particularly from Director Roberts, which the Sub-Committee will carefully review during the coming year in its study of hump yards. We will welcome written discussion of this subject. It is quite lengthy and will bear some very careful and intensive study.

There is one thing that we have not yet developed for the hump yard which we hope we may be able to develop this year, particularly those of us who have hump yards in operation. That is some more business for them.

This report is offered as information.

The President:—Are there any questions to be asked? Is Mr. Elsworth here?

Mr. R. B. Elsworth (New York Central):—My remarks on this subject are intended to be constructive. I should like to digress just a minute to say that in the capital city of the Empire State we have just built a beautiful new office building. It cost a great deal of money. They made just one little mistake and that was that they forgot the mail chute.

This Committee has presented an excellent power retarder layout. They have presented some plans in previous reports. They are splendid, but I cannot find anything in the Manual or in the Proceedings as to what the space shown between the retarders and switches is for. Referring to Fig. 1, the track layout is excellent. It shows the tower location and other details. It also shows a distance, without dimensions, between the switch and the car retarder. The purpose of that distance is to provide space for the track circuit to prevent the throwing of a switch beneath a car. There is a possibility in designing a track layout to cost many thousands of dollars for someone to draw up a layout without giving full cognizance to all the details, and it is entirely possible that an Engineer would take this layout and try to improve upon it, in his own mind, by

leaving out the distance which has been provided between the car retarder and the switch for a definite purpose.

After the plan is drawn sometimes it is rather embarrassing to change it. I have known cases, not with car retarders but with other track layouts, where the steel had actually been put in the track and had to be changed due to lack of consideration of some of the features involved.

It is suggested that in future reports the plans in some way indicate that the subject of track circuits must be decided before plan is prepared.

Mr. E. M. Hastings:—The Committee thanks Mr. Elsworth for his comment. The Chairman of the Sub-Committee received a letter from him after he reached Chicago but he did not have time to get into it very thoroughly. The matter of track circuits in the layout of retarder humps is one that has been given a great deal of attention and there is a great difference of opinion concerning it. I know of one very extensive yard which is being very successfully operated today without any track circuits. I know of another where they are having considerable trouble because of derailments, switches being thrown under cars.

The Committee will take this matter under consideration and study in its future work.

The President:—If there are no other questions, I want to say, Mr. Hastings, that you will be excused with the thanks of the Association.

Vice-Chairman M. J. J. Harrison:—Subject (8) is that of the Location and Design of Airports in Coordination with Railway Facilities. Mr. G. F. Hand, the Chairman of the Sub-Committee, is unavoidably absent. The report will be found on pages 189 to 197 inclusive of Bulletin 350. Mr. Hand has prepared and sent to me a memorandum, partly as an introduction to the Sub-Committee's report and partly in amplification thereof, reading as follows:

"This report is necessarily confined to the coordination between rail and air services at common points, and it shows what this coordination is at the present time and the requirements in respect to the location of airports and method of ground transportation between rail terminals and airports. The tabulation beginning on page 194 of the Bulletin shows the points at which the air and rail facilities are coordinated, the method of coordination, and the nature of the ground transportation. It will be noted that such coordination is quite limited at the present time, although one additional air line has scheduled air-rail connections since the report was written.

"In the past, air lines have organized their business and schedules on an entirely independent basis, except for the few cases of coordination referred to. At the present time, however, there are indications that the air lines are recognizing the fact that they do not reach the destination points of the average traveler, and if their business is to be expanded they must make the air service attractive to those who necessarily must travel part way by rail.

"This report was written five months ago and because of the rapid growth of air traffic there have been many changes since that time. However, the report presents a fair picture of the situation in respect to air and rail coordination and the principal features of this coordination have not changed since the report was written. Anyone who wishes to keep up to date should have his name on the mailing list of the United States Department of Commerce, Aeronautics Branch, so that he may receive the Air Commerce Bulletins as issued. He should also consult the Official Aviation Guide, which is published monthly and shows, among other things, air-rail connections.

"Because of financial conditions there has been somewhat of a slow-up in the development of air traffic, but there has also been a further consolidation of air lines so that,

as of January of this year, there were only 37 air transport operators in this country covering both domestic routes and routes to foreign countries.

"An examination of the airway map opposite page 190 in the Bulletin shows clearly that the air lines are organized on a national basis rather than on sectional lines as are the railroads, and consolidations which are taking place emphasize this feature. What I wish to point out is that individual railroads are not in a position to enter into the airway business. Airway business is national in character, the same as is the Railway Express Agency, and it seems to me that if the railroads are to furnish air transportation as well as ground transportation, it must be handled as a national organization participated in by all railroads, as is the express business.

"It is the experience of the Sub-Committee Chairman that operators or prospective operators of air lines consider the railroad organizations as representing the top notch in obtaining traffic and handling passenger and freight transportation, and many of these air line operators desire to take advantage of the railroads' traffic, ticket selling and station facilities, and sometimes of their rail facilities, as a foundation on which to build up their air operations.

"In any negotiations for coordination of air and rail facilities, the railroad man should not underestimate the value of his organization and ground facilities. While it is commonly considered by air line operators that the ideal method of coordination is through the use of the railroad to carry passengers from a terminal, favorably located in a city, to the airport which necesarily is located outside of the city, generally speaking, there are several vital objections to this ground transportation being via rail:

"First, locations adjacent to the tracks are seldom suitable for airports. At any rate, wire lines should be put underground and the runways located so that the trains themselves are not an obstacle to flying.

"Second, the operation of rail cars, suitable for handling passengers, on busy main line tracks is usually objectionable, due largely to interference of schedules and also to the possibility of a light rail car failing to operate automatic signals. There is usually the further complication of switching such a rail car to a siding at the airport, or of compelling passengers to walk a considerable distance to board airplanes, all of which tends to slow up the operation.

"Third, the cost of operation of a special rail car in such service is much higher than for ground transportation by means of buses. Studies made by the Sub-Committee Chairman indicate that, from all angles, the bus or limousine, operated on a schedule, provides the best method of ground transportation between rail terminals and airports.

"The air express business is growing. As of January of this year there were 46,821 miles of air lines carrying express in this country and between this country and foreign points. Of this, the Railway Express Agency ship air express over 11,331 air miles. Through coordination with railroads, the Railway Express Agency offers the only true coordination with air facilities, and there are great possibilities in this direction.

"The air lines are now serious competitors of the railroads in point of speed and cost of transportation, and if, in line with the best thought of today, the railroads are to be the one great transportation agency, it is high time that the railroads collectively take steps to operate air lines on a national basis, making use of their own individual traffic and ticket selling facilities."

This report is submitted as information and I ask its acceptance as such.

The President:—Are there any questions to be asked? If there is no objection, it will be so received.

Vice-Chairman M. J. J. Harrison:—Under the general heading of Revision of Manual, your Committee now presents the material beginning near the bottom of page 169

and continuing to the bottom of page 172 of Bulletin 350. This comprises a set of specifications for Railway Track Scale Test Weight Cars. This material was presented as information at the 1932 convention and, as explained at that time, was developed in collaboration with the Committee on Car Construction, Mechanical Division, A.R.A., and the National Scalemen's Association.

The specifications cover the following details, as designated by these section headings: Definition, Classification, Primary Requirements, Body Features, Running Gear, Brake Gear, Draft Gear, Couplers, Safety Devices, Fittings, Painting, Stenciling, Supercargo Identification, Compartment Cars.

In written discussion submitted to the Secretary of the Association when this material was presented a year ago, some revisions of the specifications were suggested. These proposals have been carefully considered by the Committee during the past year. However, since no point was raised which had not previously been carefully considered and unanimously agreed on, the Committee concluded not to recommend any changes in the proposed form.

It is moved, Mr. President, that the specifications for Railway Track Scale Test Weight Cars, as they appear in Bulletin 350, be approved for publication in the Manual, and that they be designated as Section VI, under the general heading, "Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales."

If this motion prevails, Mr. President, I will offer another motion to cover disposition of present Section VI under this heading.

The President:—Is there any discussion? Mr. Harrison, I imagine that that has also been taken up with the other bodies, outside of the associations mentioned.

Vice-Chairman M. J. J. Harrison:—Yes, sir; it has. It is agreeable to the other participants.

(The motion was put to a vote and carried.)

Vice-Chairman M. J. J. Harrison:—I now move, Mr. President, the deletion of paragraphs 2 and 3 of old Section VI of "Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales," for the reason that the material just adopted replaces these two paragraphs; the renumbering of paragraphs 4 to 11 inclusive of this Section as, respectively, paragraphs 2 to 9 inclusive, and the renumbering of the Section as VII.

The President:—Is there any discussion? Are there are any remarks? Are you ready to vote?

(The motion was put to a vote and carried.)

Vice-Chairman M. J. J. Harrison:—Your Committee at this time presents the material headed Appendix E, pages 197 to 202 inclusive, of Bulletin 350. This Appendix covers two subjects: (a) Rules for the Maintenance and Transportation of Track Scale Test Weight Cars, and (b) Definition of a Standard Test of a Railway Track Scale.

The maintenance and transportation rules virtually consist of a revision and expansion of the material appearing in new Section VII (old Section VI) of "Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales." The standard test definition is essentially new material. Both of these preparations, that is to say, Appendix E in its entirety, are here submitted as information and it is recommended that they be so received.

The President:—Is there any question or discussion? If there is no objection they will be so received.

Vice-Chairman M. J. J. Harrison:—Subject (10) is that of Bibliography on subjects pertaining to yards and terminals. The report will be presented by Mr. E. E. R. Tratman, Chairman of the Sub-Committee, who compiled the report.

While Mr. Tratman is coming forward I wish to say that the Committee feels greatly indebted to him for the careful and painstaking preparation of not only this report but also those which he has prepared in previous years.

Mr. E. E. R. Tratman:—There is not very much to be said about this. It is not a controversial subject. It is rather a list of where to find what you want to find when you want it, if you want it. They say the proof of the pudding is in the eating. If you do not eat the pudding you do not know whether it is good, bad or indifferent. If you do not use this bibliography, you do not know whether it is any good. There are occasions when a good bibliography is very useful and may save much time otherwise spent in a rather hap-hazard search for important information desired. I have cooked up the bibliography pudding and I will say this for it: It looks pretty good. I hope you can use it and I hope you like it (Applause).

Vice-Chairman M. J. J. Harrison:—I ask that the Bibliography be received as information.

The President:—That dessert was pretty short. Do you want to ask Mr. Tratman any questions on it? If there is no objection, it will be received as information.

Vice-Chairman M. J. J. Harrison:—As indicated on page 167, your Committee desires to report progress at this time on the remaining subjects which were assigned to us, namely, 3, 4, 5 and 7, as they appear in the outline of work.

Unless there is something further that you desire to take up, Mr. President, that concludes the current report of the Yards and Terminals Committee, and I move its acceptance.

The President:—If there is no objection it will be so accepted. Are there any questions that the members here would like to ask this Committee? In the operation of trains over the right-of-way, particularly the last few years, and in analyzing that movement, a great deal has been said and written about the speed between one terminal and the other. Your freight train movement has been making unusually high speed, another story of the expediting of traffic. The railway executives, in analyzing this in the past few years, have found that the trains cover their Division runs at exceptionally good speed but lay ten or more hours in their terminals.

I think, with the hump yards and the classification of yard movements, that time has been cut down materially. That has aided materially in connection with expediting traffic. I thought I would mention that because this Committee on Yards and Terminals, which may not get the recognition, has contributed to the simplification of movement on railroads in general. They are excused with the thanks of the Association (Applause).

Mr. Harrison, do you still think you should not have air brakes on scale test cars?

Vice-Chairman M. J. J. Harrison:—Yes, sir.

DISCUSSION ON SHOPS AND LOCOMOTIVE TERMINALS

(For Report, see pp. 251–260)

Mr. L. P. Kimball (Baltimore & Ohio):—The report of the Committee on Shops and Locomotive Terminals will be found in Bulletin 350, beginning on page 251. This year the Committee is presenting reports on three subjects: (3) Firing-Up Stations for Locomotives; (4) Turntables; (5) Application of Unit Heaters to Shops and Locomotive Terminals.

In the enforced absence of Mr. Laffoley, Chairman of Sub-Committee (3), I will undertake to present his report for the Committee. This report is found in Appendix A, page 251, and the report in its entirety is in the shape of conclusions, which are presented as information only.

The President:—Are there any questions? Is there any discussion? If there is no objection, it will be so received.

Mr. W. F. Steffens (New York Central):—Before we leave that subject, I believe that the number of railroad men present warrants a special word of caution about firing-up of locomotives. A very serious fire several years ago resulted in the destruction of an entire plant due to a homemade, pressure, fuel oil device left by the employees for a few moments to get their luncheon handy before finishing the job. They returned to find the supply hose disconnected from the device, and the entire plant in flames. The total loss of this structure occurred in Indiana, not so far from where we are meeting today.

The Committee has fortunately recognized the aspirating device, the vacuum system. There are obtainable vacuum systems, complete portable devices for firing-up locomotives that come into shops and terminals. Before the Committee leaves this subject, I certainly and sincerely trust, on behalf of the Railway Fire Protection Association, that a little more stress will be placed on the vacuum system which is absolutely safe, inasmuch as if the air supply fails the oil simply runs back to the supply tank and there is no hazard involved. May I call that to the attention of the Committee most respectfully as a comment from an outside organization?

Chairman L. P. Kimball:—We would be very glad to take that into account. The Committee perhaps has not laid enough stress on the difference between the two systems. Both systems are in use and the information as to present practice was presented as information.

The next subject is that of Turntables and will be presented by Mr. J. M. Metcalf, Chairman of that Sub-Committee.

Mr. J. M. Metcalf (Missouri-Kansas-Texas):—The Committee submits as information, on pages 254 to 256 of Bulletin 350, a brief discussion of the functions of turntables, their place in locomotive terminal design, and essential general features of construction and maintenance. It has not undertaken to go into the more technical study of design and specifications for turntables, which has been thoroughly covered by Committee XV—Iron and Steel Structures, whose conclusions, in the form of specifications for steel railway turntables, appear in the 1929 Manual, pages 1234 to 1239.

The Committee recommends that its conclusions, Nos. 1 to 10 inclusive, as printed on page 256 of Bulletin 350, be substituted for the matter now included under the sub-heading "Turntable" and "Turntable Pit," under the subject heading "Engine House Design," on page 1471 of the 1929 Manual, as revised by paragraph (a) under "Engine House Design," page 71 of Bulletin 347.

I move that these conclusions on page 256 be adopted.

Mr. B. R. Leffler (New York Central):—Since these conclusions are to go into the Manual, it might be well to look them over a little bit.

The President:—Would you like to have Mr. Metcalf read them?

Mr. B. R. Leffler (New York Central):—I think they should be read.

The President:—They will be so read. Please read each paragraph and then pause to see if there is any discussion of it.

Mr. J. M. Metcalf:—"1. Use of a three-point turntable is preferable where long locomotives are to be handled. If balanced type table is used, it should be long enough to balance the locomotive when tender is empty."

Mr. B. R. Leffler (New York Central):—I would say that that might have a bearing on the converting of the old tables into three-point tables. It is not necessary to have the three-point type if you put in new end trucks of sufficient capacity and heavy enough tractors. Take the ordinary balanced type table. By this device you can quite often save considerable money and make the old table serve for years to come.

Mr. J. M. Metcalf:—That is true and is recognized in the discussion. We did not include anything on that matter in the conclusions. I think it is a matter of design which properly should be gone into in detail by the Committee on Iron and Steel Structures rather than by this Committee. We have brought out in the discussion the fact that such conversion is practicable.

Mr. B. R. Leffler:—I think it should be recognized here if this is to go into the Manual.

The President:—It appears to me that Mr. Leffler is right. On certain roads the one-point bearing table has been converted into the three-point bearing table. The design and modification of that conversion has been handled by the Bridge members in collaboration with the Steel members. Am I right, Mr. Leffler?

Mr. B. R. Leffler:—That is right.

The President:—I think Mr. Leffler's point is that No. 1 should be broadened just sufficiently to cover that modification. Is that correct?

Mr. B. R. Leffler:—That is correct. I suggest it be so modified.

The President:—I do not suppose it would do any harm to add that, would it?

Mr. J. M. Metcalf:—No.

The President:—And extend its scope? Would you have any objection, Mr. Leffler, to letting the Committee be the judge as to modifying the paragraph to cover that point?

Mr. B. R. Leffler:—That will be satisfactory, so far as I am concerned.

Mr. J. M. Metcalf:—"2. A deck turntable is usually more economical, but in the balanced type a through table may be desirable where use of a deck structure would greatly increase the cost or make satisfactory drainage difficult."

"3. Where modern heavy locomotives are to be turned, mechanical power for operating turntables should be provided. Where current is available, electricity is the most reliable means of operating a turntable. The power wires should be led to the table underground and so arranged as to minimize danger of interruption of supply in case of fire in the engine house or other emergency. Where electric power is not available, a compressed air motor may be used."

Mr. B. R. Leffler:—I have a few points I want to bring out on that point—"The power wires should be led to the table underground." I think there is a chance and possibility of a great difference of opinion. We used to do it that way and gave it up; we now bring the wires up over the top to a properly constructed frame over the center of the turntable. There are many advantages. You can see the wires; they are not subject to flood conditions. I should like to ask whether the Committee has considered the matter from all angles.

Mr. J. M. Metcalf:—The Committee discussed that question and it was the view of a number of members of the Committee that overhead wires were in more danger from fire, more liable to interruption from various causes, and that the underground construction was preferable.

Mr. B. R. Leffler:—I am inclined to think that if this convention could be polled on this detail there might be a great deal of divergence from that conclusion. I know that the electrical department of our part of the railroad, in my own personal experience, is against bringing the wires up through the center. I should like to ask: Has the Committee covered the matter by questionnaire?

Mr. J. M. Metcalf:—We did not. We would be glad to know the reasons for considering the overhead construction preferable in view of the danger of fire, wind and other possible accidents.

Mr. B. R. Leffler:—It seems to me that the question of fire and wind is a matter of design. We are not putting everything underground to get rid of fire and wind.

Mr. J. M. Metcalf:—What are the advantages of the overhead construction, if I may ask?

Mr. B. R. Leffler:—The wires can be inspected, which is a great advantage from a maintenance standpoint. Another advantage is that all of the contacts can be seen and are not buried underground, beneath the table, where water and dirt and other obstructions can put the table out of service.

Mr. J. M. Metcalf:—Do such objections hold against a properly constructed underground conduit, such as is customary for power wires?

Mr. B. R. Leffler:—I do not know, but we have not been very successful in that. Perhaps we have not had sufficient designing skill. Anyhow, I think this is not a matter that should be passed upon and put into the Manual without having it very carefully passed upon by Electrical Engineers as well as Structural Engineers. I think the field should have been canvassed by a thorough questionnaire. I am not in favor of questionnaires as a cure-all, but I think a proper questionnaire on this would bring out some interesting points as to practice.

The President:—Is there anyone else who would like to make some remarks on that paragraph?

Mr. G. S. Fanning (Erie):—If our practice is any indication of what ought to be done, I certainly agree with Mr. Leffler, because all our installations are overhead.

Mr. O. E. Selby (Big Four):—I support Mr. Leffler in his contention that the wires should be overhead. In the interest of safety and simplicity of maintenance, that should be done. I think Mr. Leffler is wrong in his other contention that he made a few minutes ago with respect to putting in the report the alteration of the balanced table into the three-point bearing table, but it is a pleasure for me to agree with him on this point.

I think this paragraph should not go into the Manual without further consideration.

Chairman L. P. Kimball:—Apparently the New York Central Lines have been so fortunate as not to have had experience with fire similar to one of the engine houses that I happen to know of on the Baltimore & Ohio. In that case we lost a frame engine house with 35 engines stored in it at the time. The turntable early in the fire went out of service due to the fact that the wires to the operating equipment were overhead. If those wires had been underground we probably would have been able to get a large number of those locomotives out and away from the fire. It was the thought of the Committee, while recognizing the accessibility of overhead wiring connections with turntables, that the safety, from a fire protection standpoint, of the underground wires justified the recommendation as contained in the conclusion.

Mr. O. E. Selby:—I think the example of a frame engine house should not be given much weight. I am sure nobody here wants to advocate the use of frame engine houses. In the case mentioned by the Chairman of the Committee, the destruction of the wires to the turntable equipment would have been avoided by a proper installation of those wires. I have no doubt that the wires, in the case he mentioned, ran directly from the engine house to the turntable. If there had been a proper installation of the wires, with an independent route from the source of power to the overhead frame, there would have been little likelihood of the trouble occurring.

Another feature that is important is the drainage, the flooding of the turntable pit. There is a great deal more likelihood of the turntable pit being flooded than there is of the engine house taking fire. Turntable pits of good design, with proper drainage, may from time to time be flooded by the stopping up of drains or by excessive snowfall. A great many things of that kind can happen, whereas a fire happens once in a great many years.

Mr. Arthur Ridgway (Denver & Rio Grande Western):—I do not know whether it makes any difference to this Committee reporting on turntables as to how the wires are brought to the turntable. Probably none of us would wire a turntable except in the manner which we thought was best under the circumstances anyway. I do not like to see the conclusion thrown out because of the peculiar wording of it. I wonder if the Committee would be willing to accept this for the third sentence: "The power wires should be led to the table in such an arrangement as to minimize danger of interruption of supply in case of fire in the engine house or other emergency." That leaves the choice of underground or overhead, whichever is better.

Mr. J. M. Metcalf:—The Committee would have no objection.

Mr. L. B. Allen (Chesapeake & Ohio):—I wish not to agree with that because I think it is the province of this Association to recommend the best practice. We should not leave it up in the air. One of these ways is the better way. They either should be put underground or overhead. Some peculiar circumstance or location may change that in special cases. In general, one method or the other is the better method, one is better from the fire protection standpoint and the other from a drainage standpoint. It seems to me that as the wiring for signal and other work is put underground, this could be put underground without fear of trouble or interruption to service due to drainage. I should very much like to see the Committee go on record with a definite recommendation.

The President:—I do not believe anybody seconded Mr. Ridgway's motion. Was that in the form of a motion?

Mr. Arthur Ridgway:—No. I just asked if the Committee would be wil ing to accept that change.

The President:—As a suggestion? The Committee, as I understand it, had no objection to it.

Mr. B. R. Leffler:—If the discussion is about closed, I was going to make a motion to the effect that Conclusion No. 3 be referred back to the Committee for further study.

Mr. J. A. Peabody (Chicago & Northwestern):—I have not much to say except about one feature of this proposition. It is easy enough to put cables under a railroad and have them safe, but to carry those wires up on the turntable is another matter. To keep them free from trouble due to improper drainage is a difficulty that is being experienced everywhere. I know that in our own case we have had wires underneath and we have taken them out and put them overhead, preferring the good day-by-day operation to the possibility of difficulty in case of fire emergency. We do not have fires very often, and we use the turntables every day.

I would therefore suggest that this be sent back to the Committee for further consideration or the elimination of that third sentence entirely.

In order to get it before the Association properly, I move the elimination of the third sentence.

The President:—Please read the sentence to be eliminated.

Mr. J. A. Peabody:—"The power wires should be led to the table overhead and so arranged as to minimize danger of interruption of supply in case of fire in the engine house or other emergency."

Mr. B. R. Leffler:—That does not answer the question. The Association does not want to evade a question because they cannot answer it. Which is the better practice is the question, overhead or underground?

I am in favor of turning it back to the Committee for further study to answer that question. I so make a motion.

Mr. Arthur Ridgway:—I move an amendment to the motion that is before the house, that only a part of the third sentence be eliminated, so that it will read this way: "The power wires should be led to the table in such an arrangement as to minimize danger of interruption of supply in case of fire in the engine house or other emergency."

The President:—Is there further discussion?

Mr. O. E. Selby:—I second Mr. Ridgway's amendment.

The President:—Mr. Peabody, have you any objection to the last amendment?

Mr. J. A. Peabody:—I could not hear it.

The President:—Will you please repeat it, Mr. Ridgway?

Mr. Arthur Ridgway:—It is the elimination of four words and the substitution therefor of four, so that the sentence will read this way: "The power wires should be led to the table in such an arrangement as to minimize danger of interruption of supply in case of fire in the engine house or other emergency."

Mr. L. B. Allen:—We are still begging the question. I think we ought to determine which way it should be done if we are going to put this into the Manual and go on record as a recommended practice.

Mr. J. A. Peabody:—I do not believe that fully covers the idea. I do not believe that the danger of fire is the important one. Really the important thing is the day-to-day operation. That is the thing of most importance. Therefore, I believe that the whole matter must go back for reconsideration.

The President:—You are talking now about No. 3. That has been seconded.

Mr. B. R. Leffler:—The original motion was made to that effect.

The President:—I am trying to find out how many of these we have to vote on at a time. I want to give all you fellows a whack at it to see if we can improve it.

The President:—Mr. Leffler, would you object to voting on the last motion?

Mr. B. R. Leffler:—According to parliamentary procedure, I think you have to recognize the motion and the amendment that was seconded. Vote that down and then come to my motion.

Mr. G. S. Fanning:—I do not believe that we ought to send it back to the Committee. It is something that could be settled here. I should like to make a further amendment, so that the third sentence will read: "The power wires should be led to the table overhead and so arranged as to minimize danger of interruption of supply in case of fire in the engine house or other emergency." That is changing the one word "underground" to "overhead."

Mr. B. R. Leffler:—I had the same idea. I wanted to be a little more lenient toward the Committee and give them a chance to study it more. I am ready to vote on "overhead," so far as I personally am concerned.

Mr. L. B. Allen:—I do not think we ought to decide here on this "overhead." I think we ought to send it back to the Committee and let the Committee give the matter some further study or send out a questionnaire and decide it on its merits, instead of trying to decide it here on the floor with so much division of opinion. I should like to get a vote one way or the other, though it might not be an indication of what is the proper practice. This Association certainly ought to be able to develop what is proper and then recommend it.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—Inasmuch as this Committee has not had time to study this subject, here in convention we take a half-baked idea that each of us may have and try to put it over with possibly just an impulsive notion in our heads. That is not fair to the Committee that has given this study. That is why I prefer to have it referred back to the Committee for further study and consideration of the views that were expressed on the floor.

The President:—I did not want to get into this discussion from a personal angle, but I am glad it came out because you have not got the engine house gang in this yet. If you go out to the round house gang, which is a pretty tough gang, you are going to find more trouble with feeding the motor to give them power to turn the table with a wire underground, instead of leading the wire from the building to the motor to turn the table. There are certain locations where I think the underground is the better; at other locations I think the overhead is the better. For the round house gang, you will find you will have less confusion with the overhead than with the underground. That is my own personal opinion. I think we ought to settle this one way or the other or turn it back.

Mr. G. S. Fanning:—Question!

The President:—The first amendment is to change this Rule No. 3 from "underground" to "overhead." Is that correct? Are you ready for the question? All in favor say "aye"; contrary, "no." The "noes" have it.

Mr. B. R. Leffler:—What about my amendment?

The President:—Mr. Leffler, the original amendment stands now, I think. It was to refer it back to the Committee for further study.

Mr. Edwin F. Wendt:—If I remember correctly, Mr. Ridgway's amendment would be next in order.

The President:—Mr. Ridgway's amendment is now in order. His amendment was in regard to changing the third sentence of that paragraph. Do you want the paragraph read again? Do you all understand the amendment? All in favor will says "aye"; contrary, "no." The amendment is lost.

The next is Mr. Leffler's motion. The motion is to refer it back to the Committee for further consideration.

Mr. Arthur Ridgway:—The next amendment was that we eliminate the third sentence entirely.

The President:—Mr. Peabody's. I guess he is right. The next one is to eliminate the third sentence entirely. Well, we are going to vote on it anyway. All in favor will say "aye"; contrary, "no." That amendment is lost.

The next is Mr. Leffler's motion to refer paragraph No. 3 back to the Committee for further consideration. All in favor will say "aye"; contrary, "no." The "ayes" have it, and the motion is carried.

Proceed, Mr. Chairman.

Mr. J. M. Metcalf:—"4. The deck of the turntable should be wide enough to provide a walk on each side, and should be protected with handrails."

The President:—Is there any discussion?

Mr. J. M. Metcalf:—"5. The turntable pit should be paved and adequately drained."

Mr. B. R. Leffler:—No 4 makes it really mandatory to have a walk on each side. There are a good many places where a walk on one side ought to be enough.

Mr. J. M. Metcalf:—The Committee does not agree with that. I think a walk on each side is certainly desirable. It should be wide enough to provide a walk on each side.

Mr. B. R. Leffler:—I just want to bring out the point that at a small terminal that may not be necessary.

The President:—If there is no further objection, you will proceed.

Mr. J. M. Metcalf:—"6. The circle wall should preferably be of masonry, with proper supports and fastenings for rails on the coping. A timber or steel coping is preferable to a rigid masonry coping."

Mr. Meyer Hirschthal:—Do you mean concrete masonry? "Masonry" is a rather indefinite term; it may be brick, concrete or stone. Is it the thought of the Committee to have this concrete masonry?

Mr. J. M. Metcalf:—To have it concrete, yes.

The President:—And the Committee will accept that?

Mr. J. M. Metcalf:—Yes.

"8. Easy access to the parts of a turntable for the oiling of bearings, painting and inspection should be provided in the design of the pit, unless ample provision is made in the turntable itself."

Mr. B. R. Leffler:—I just want to call attention to the fact that in the Manual, page 1239, the inspection pit itself is made mandatory. The conclusion is all right, but it has been based upon the requirement in the Manual.

Mr. A. R. Wilson (Pennsylvania):—In some cases with the three-point table we found it desirable to put a well or hole in the circle wall for inspection and renewal of the trucks. In No. 8, where it says that point should be provided for in the design of the pit, it may include this feature. Otherwise, I think some note should be made of it.

Mr. J. M. Metcalf:—It is the intention to include just that feature in this provision.

"9. Thorough lubrication, systematic cleaning of both table and pit, and careful inspection at regular intervals are essential to satisfactory operation of a turntable. The table should be raised and center thoroughly inspected at least once a year."

Mr. B. R. Leffler:—There should be no more occasion for raising a turntable and examining the center than to raise a 250-foot vertical lift or a bascule bridge to examine the trunnions. If the turntable center is of proper design and properly lubricated, such inspection once a year is not necessary. We have a flat disc center that has been in use for twenty years and it has been well lubricated. About three years ago we took it up just to see whether it was nice and smooth. It was as beautiful as a mirror. I do not think it will be necessary to take that center up for another twenty years. This idea of taking up the center of the turntable is a confession of poor design originally, and the difficulty is found mostly with roller-bearing centers, thrust washers grinding to pieces, thrust balls grinding to pieces, centers becoming flooded with water and dirt diluting the oil. I am not objecting to the conclusion very strongly, but I do not know that it should go into the Manual. I do not think there is any particular need of its going into the Manual.

The President:—Is there any other objection? Do you have any serious objection to leaving it as it is?

Mr. B. R. Leffler:—It does no harm, but I think it is loading the Manual with something that is not very valuable.

Mr. J. M. Metcalf:—"10. Radial tracks should be kept in good line and surface. Radial track and turntable rails should be maintained with proper spacing between their ends and at proper relative elevation."

Mr. B. R. Leffler:—There is something else, an interesting point. The Committee has not said anything in these recommendations about proper turntable centering devices at the ends, locking devices. There are a number of simple devices which can be and are being used and such devices will prevent derailment of locomotives going off and onto the table.

The President:—I believe the Committee will be very glad to give that consideration in their future work. That is particularly true on the single-point or the modification of the single-point table. On the three-point table you will find that the engine house crew will not use them, but by some proper locking device you can avoid a lot of derailments in case your table is not in the proper position.

Will you make a motion on these conclusions?

Mr. J. M. Metcalf:—I make a motion that we adopt these conclusions with the elimination of No. 3.

The President:—Is there any more discussion?

(The motion was put to a vote and carried.)

Chairman L. P. Kimball:—The next subject, (5), Application of Unit Heaters to Shops and Locomotive Terminals, is found in Appendix C on page 256. This report will be presented by Mr. Murdock, Chairman of that Sub-Committee.

Mr. B. M. Murdock (Illinois Central):—The report gives a general outline of the customary methods of industrial heating prior to the advent of unit heaters. Following that is a description of the various types of heaters, selection of system, size and selection of heaters, location of heaters in shop buildings, the use of heaters in the engine houses, also remarks on automatic control and quietness of operation.

The information set forth is based on a study of the various types of well-known and established heaters on the market, together with practical experience gained by a number of the railroads through their use of such equipment in shops and locomotive terminals. Your Committee has worked in close cooperation with the leading manufacturers of this equipment and they have been given every opportunity of expressing their views and recommendations on the subject, and the remarks so received have had the Committee's serious consideration.

The information here presented is in accord with the recommendations of the American Society of Heating and Ventilating Engineers. It is recommended that the report be accepted as information.

The President:—If there is no question or discussion, it will be so received.

Chairman L. P. Kimball:—That is all.

The President:—Does anybody want to ask any question of this Committee? I am glad we had this interesting discussion. The Committee is excused with the thanks of the Association (Applause).

DISCUSSION ON RECORDS AND ACCOUNTS

(For Report, see pp. 209–250)

(Vice-President John E. Armstrong in the Chair.)

Vice-President John E. Armstrong:—The report of the Committee on Records and Accounts will be submitted by its Chairman, Mr. C. C. Haire, Engineer Capital Expenditures, Illinois Central System. Mr. Haire will please point out the salient items of importance and tell us what action is desired.

Mr. C. C. Haire (Illinois Central):—The report of the Committee on Records and Accounts is found on page 209 of Bulletin 350. It covers fourteen assignments dealing with accounting, valuation and allied subjects. The first assignment of the Committee is the usual subject, (1) Revision of the Manual. The Committee has not made a definite report this year but has given consideration to revision of the material through the work of other Sub-Committees. This is particularly evident in the report covering the valuation subject, which will be presented later.

One of the obstacles that has prevented any extensive revision work is the contemplated changes in the accounting classifications and the depreciation order; also, the modification of certain valuation orders made effective the first of this year. All of these things have a tendency to affect the future work of the Committee on Records and Accounts. There is, naturally, a tendency to withhold any revisionary work until conditions become more stabilized.

The second assignment the Committee presents is the one covering Bibliography on Subjects Pertaining to Records and Accounts. The Committee has compiled a report as Appendix A, and, owing to the absence of the Chairman of the Sub-Committee, I will merely call your attention to the compilation, similar to what has been done heretofore.

Under the next group of subjects, the Committee presents a report on Office and Drafting Room Practices. This is shown under Appendix B. To a certain extent the material presented is a revision of what has heretofore been published in the Manual. I will ask Mr. Avery, Chairman of the Sub-Committee, to present that report.

Mr. D. L. Avery (Chesapeake & Ohio):—Report of Committee B-1, Drawings and Drafting Room Practice is found on pages 212 to 233, inclusive, of Bulletin 350.

Your Committee has undertaken the revision of the present Symbols shown on pages 745 to 757, inclusive, in the Manual. It has worked with such A.R.E.A. Committees and is using such data prepared by the American Standards Association as comes under the subject assigned them.

The subject has been divided into two parts: (A) Engineering Symbols and Office Practice, and (B) Electrical Symbols and Office Practice, (a) General, (b) Signal.

The first group of Symbols has been prepared and is submitted hereafter as Exhibit 1. This Exhibit comprises nineteen sheets which cover thirty-five subjects. A total of 500 different symbols are shown.

The Committee has not had sufficient time to thoroughly study this subject and submits Exhibit 1 as a progress report only. It recommends that the subject be continued in order that this Exhibit may be revised and that the Electrical Symbols may be prepared. The subject will be continued progressively.

This report is offered as progress only.

Vice-President John E. Armstrong:—Is there any discussion?

Mr. J. C. Irwin (Boston & Albany):—I want to express a note of confidence in the work of this Committee. They are working in cooperation with the American Standards Association and I know that this Committee is getting proper collaboration from Sectional Committees of the A.S.A. and also from the Signal and Electrical Sections. Under Mr. Haire's direction, I think Mr. Avery and Mr. Walsh and the others are proceeding in the best line possible. If they continue as they are going, the results of their work will be very valuable.

Vice-President John E. Armstrong:—Is there any further discussion?

Mr. W. A. Radspinner (Chesapeake & Ohio):—On page 221, under Fire Prevention, I think there should be included some symbol to indicate the post indicator valve. This valve is used around buildings protected by automatic sprinklers and similar water line protection systems. It is a separate valve, from the fire hydrant. I think it should have some special designation.

Mr. D. L. Avery:—We will be glad to consider that before next year's report.

Vice-President John E. Armstrong:—Is there any further discussion?

Mr. A. R. Wilson (Pennsylvania):—I think it unwise for this Committee to indicate the proportion of rivets or bolts, referring to pages 226, 227 and 228. Using these dimensions is all right. The proportion of these units should be covered in the Manual by other Committees.

Mr. D. L. Avery:—In this connection, you will find that the trackwork plans indicate U. S. Standard thread for all bolts. On page 173 of the Manual, U. S. Standard threads and nuts are shown for track bolts. The Committee intends to show the present practice as called for under our plans and specifications. If changes are to be made in our present practice, such changes will be reflected by the report of this Committee.

In connection with the rivets shown on page 226: I have taken this up with the Chairman of the Bridge Committee, and certain features shown will be eliminated before these symbols are adopted for use.

Vice-President John E. Armstrong:—Are there any further questions or criticisms, gentlemen? If not, the report will be received as requested by the Sub-Committee.

Chairman C. C. Haire:—The next assignment given the Committee is on page 234, Joint Facility Records. The report as shown is a progress report, with no definite conclusions, as we have been unable to complete the subject this year. We ask to carry it over for another year and hope to complete the work in 1933.

Vice-President John E. Armstrong:—Any question or discussion, gentlemen? If not, the report will be received as a progress report.

Chairman C. C. Haire:—The next subject on the Committee's docket is one that has been with us quite a while. We regret that we are unable to present a final report this year. We have come forward for the last three or four years, I believe, with a similar story. We found it impracticable to design a series of reports from the conflicting views of the five collaborating Committees. However, I think there is now a method that will permit of completing the subject this year.

Vice-President John E. Armstrong:—Is there any discussion on Appendix C, gentlemen? If not, it will be received as information.

Chairman C. C. Haire:—Under Group C, Maintenance of Way Reports and Records, the Committee's first assignment covered Statistical Requirements of Operating, Accounting and Other Departments with Respect to Maintenance of Way and Structures. The Sub-Committee's report is shown as Appendix D, and Mr. Cummings, Chairman of the Sub-Committee, will present the report.

Mr. W. F. Cummings (Boston & Maine):—The report of this Committee is shown on page 235 in Bulletin 350. The function of this Sub-Committee is to study progressively and report as to forms and data called for on chart shown on page 278, Vol. 27 of the Proceedings.

The Committee this year has undertaken to present a form of daily report on work equipment in service. The form is shown on pages 236 and 237 and the Committee asks that the report be received as information and the subject continued.

Vice-President John E. Armstrong:—Is there any question or discussion, gentlemen? If not, the report will be so received.

decided to make a separate report for the following reasons: A great number of the wat stations consist only of the pumping and water storage facilities. For such stations tl information dealing with treatment would be useless. There are also stations consisti only of water treating facilities, usually where the water supply is furnished by a cit In such cases the information on water production would not apply. Principally d to these reasons the Sub-Committee has made two separate forms. I might add that tl Sub-Committee was informed and believes that the treatment should be kept as separa from water production as possible. This is one method by which the treatment can l kept separate from water production.

Mr. E. M. Grime:—I see no reason why you cannot get along with one form. have been using one form on the Northern Pacific for about five years very satisfactori under all conditions, condensing and combining some of the headings that are given c this form.

This form also contains one or two headings which seem to be impracticable, th is, they require information which, if given by a pumper, would not be reliable. I a certain the Form 1301 can be easily changed to include all essential data for which th new form is designed.

Chairman C. C. Haire:—Mr. President, I should like to call attention to the fa that the work of this Sub-Committee is joint with the Water Service Committee. As matter of fact, they are working hand in glove with the Water Service Committe and everything that we present here bears the stamp of approval of that Committee, a I understand it.

Mr. E. M. Grime:—I may be in the minority, gentlemen, but I still feel that w are making a mistake in recommending two forms for this very simple matter.

Vice-President John E. Armstrong:—The Committee is holding the matter up fc another year for consideration before presenting the information for adoption and in clusion in the Manual, and I have no doubt they will reconsider the matter if there further discussion or pressure on that point. Is there any further question or discussio gentlemen?

Mr. R. C. Bardwell (Chesapeake & Ohio):—The report of this Sub-Committee wa referred to Committee XIII—Water Service and Sanitation, and approved by them a their last meeting. Unfortunately, Mr. Grime was not present at this meeting and di not have the benefit of the discussion at that time.

It was our understanding that this Sub-Committee had secured forms covering suc reports from practically every railroad where such forms are in use. There were a grea variety of these forms. The report which is presented by this Sub-Committee consoli dates the various information obtained.

It is our further understanding that recommended forms appearing in the Manua are to be used as a guide for the individual requirements on a particular railroad instea of being followed verbatim. If any railroad desires to consolidate these two forms fo their own particular need there should be no objection. For these forms, as a whole, i was felt that the information shown is of value to those who desired the use of tw forms.

This report was approved by Committee XIII as it stands.

Vice-President John E. Armstrong:—If there is no other discussion the matter wi be held open for another year as requested by the Committee.

Chairman C. C. Haire:—The next report that the Committee wishes to present i one covering the valuation subject. This report is shown under Appendix G, and in th absence of Mr. James, Chairman of the Sub-Committee, Mr. Stroebel will present th report.

Mr. H. J. Stroebel (Erie):—The purpose of the Committee this year has been to review the forms previously submitted by Committee XI and, after carefully considering the entire situation in a broad manner, determine which forms are obsolete and of little use; which forms should be held in abeyance; and which should be retained, with or without revision. The Committee has had in mind that a proposed new uniform system of accounts embodying depreciation accounting is under consideration; consequently, it has been thought best to held certain matters in abeyance for the present.

Since the work of compiling Appendix G was completed, the Interstate Commerce Commission, in a series of orders dated November 25, 1932, modified, suspended and cancelled certain Valuation Orders, effective as of January 1, 1933.

These are: (1) Revision of Supplement No. 4 to Valuation Order No. 3, cancelling previous Order; (2) Revision of Supplement 5 to Valuation Order No. 3, cancelling previous Order; (3) Revision of Supplement No. 6 to Valuation Order No. 3, cancelling the previous Order; (4) Revision of Map Order cancelling previous Map Order; (5) Order suspending Valuation Order No. 25, pertaining to the accounting reports; (6) Order cancelling Valuation Order No. 15, pertaining to privileges given and to leases made by steam railroads.

By reason of the suspension of Valuation Order No. 25, a change should be made in Appendix G, page 246 of Bulletin 350, Section 24, in the third line from the last, wherein the words reading "Valuation Order No. 25" should be eliminated and in place thereof the words "Revised Supplement No. 5 to Valuation Order No. 3, Second Revision Issue, Effective January 1, 1933" should be inserted.

In the past, considerable attention has been given to forms relating to valuation matters. The Committee feels that study should be given to other phases of the subject, therefore, the work this coming year will be directed principally to a study of forms pertaining to other than valuation records. This report is submitted as information.

Vice-President John E. Armstrong:—Is there any discussion or question, gentlemen?

Past-President Edwin F. Wendt:—I desire to express my appreciation of all of the work of this Committee.

You know that the National Transportation Committee has recommended the repeal of the recapture provision of the Interstate Commerce Act, and there are excellent prospects of the adoption of the recommendation of that committee.

Twenty years ago in 1913 the Valuation Act was passed by the Congress and at that time the Committee on Records and Accounts began its consideration of the subject of valuation.

You will remember that Section 19-A of the Interstate Commerce Act requires the Commission to prepare the valuation of all of the property of each and every common carrier in the United States, and to present a report to the Congress each year. The Commission is now fully informed and no doubt will make a statement of the valuation of all the railroad properties of the United States as of one common date.

There is another phase of the valuation problem which merits a moment's notice. You know that the Rock Island Railroad is the first of the great railway systems in this country to file an application for the approval of the consolidation of all of its property into one corporation. When a railroad system desires public approval for the consolidation of its various component units into one organization, the law provides that before the Commission gives it approval it shall value the consolidated property. I understand that work has been in progress for a number of months in order to determine the value of the Rock Island System for consolidation purposes.

This brings up the interesting question as to what constitutes the value of a railroad under the consolidation section of the Interstate Commerce Act. Heretofore, you will remember, the Commission has determined the valuations for ratemaking purposes

under Section 15-A, but the question now comes up, and it is a most interesting one, I think, from the standpoint of the Engineer, as to what constitutes value in the case of consolidation.

So in this year of 1933, twenty years after the passage of the Valuation Act, we find the results of the valuation work for the first time being put to practical use such as is required by the law.

I mention these matters because you will remember that the United States Supreme Court decided that the valuation reports prepared by the Commission under Section 19-A and presented to the Congress were not reports which could be set aside by the courts, because the Supreme Court held that no damage was done by such reports.

Now, when the valuation is about to be used for some specific purpose such as consolidation, it seems to me we have entered a new phase of the entire subject, and I feel that possibly an epoch will be marked by finally determining what constitutes the value of a railroad for the purpose of consolidation.

Vice-President John E. Armstrong:—Thank you, Mr. Wendt. If there is no further discussion on this Sub-Committee's report, it will be accepted as a progress report.

Chairman C. C. Haire:—The next assignment of the Committee is shown on page 246, Methods Used in Recapture Proceedings, Appendix H. Mr. Silliman, the Chairman of the Sub-Committee, has compiled a statement showing what has been transpiring in the recapture work and pending Federal legislation and regulation. The report is submitted as information.

Vice-President John E. Armstrong:—Any discussion or question, gentlemen? If not, the report will be so received.

Chairman C. C. Haire:—The next subject the Committee presents is information covering revision of the accounting classifications. These have been held up and nothing definite has developed, so the Committee merely reports progress this year.

Vice-President John E. Armstrong:—The report will be so accepted.

Chairman C. C. Haire:—The next subject is Developments Under I.C.C. Order No. 15100—Depreciation Charges of Steam Railway Companies. Mr. Kettenring, in the absence of Mr. Hande, Chairman of the Sub-Committee, will make the report.

Mr. W. R. Kettenring (Chicago & Northwestern):—The Depreciation Order is so closely allied with the accounting classification that we can make little progress on one without making progress on the other. The Committee has made four previous reports on this subject, and now submits its next report.

As previously reported, the Commission released its Depreciation Order in July, 1931. In March, 1932, it was postponed one year, and in February of 1933 it was again postponed, so the effective date is now January 1, 1935.

The Committee wishes to state, however, that it has made substantial progress toward developing a complete report on recommended procedure and forms under the joint requirements of the Depreciation Order, and the classifications which were released to a limited number of accounting officers in March, 1932. This work can be brought into accord with the final text of the classifications soon after their promulgation. Discussions will be continued in the Sub-Committee with regard to recommended procedure and forms to the end that the report may be as complete and representative as possible, and be ready for publication if and when the new classifications are formally made effective by the Commission.

Vice-President John E. Armstrong:—Is there any discussion, gentlemen?

Mr. Robert H. Ford (Rock Island):—The Committee is doing splendid work and their report is both profitable and instructive.

It is interesting to know that they are closely following the results of the depreciation proposals contemplated under I.C.C. Order 15100. Without attempting to dis-

cuss the purpose or objectives of this Order, it is becoming increasingly evident that unless substantially altered, its application will greatly increase the burdens and costs already imposed on the railroads by Federal mandate. It will add additional employees, additional accounting, additional forms and records, and expensive and wholly unnecessary requirements in other directions.

Simplified Federal processes, rather than further complicated ones, are badly needed if the best interests of the public and the rail carriers are to be served.

The application of this Order as presently proposed further complicates an already heavily burdensome situation. It is a fruitful means of adding to the Federal bureaucracy which everyone should be anxious to avoid.

Vice-President John E. Armstrong:—Is there any further discussion, gentlemen? If not, the report will be received as presented by Mr. Kettenring.

Chairman C. C. Haire:—The Committee has an assignment, Methods for Avoiding Duplication of Effort and for Simplifying and Coordinating Work Under the Requirements of the Interstate Commerce Commission. That is shown under Appendix J. This subject has been with us for sometime and we have another progress report to be presented by Mr. Sharood. He is also Chairman of the next Sub-Committee to report, and he will present both subjects at the same time.

Mr. F. C. Sharood (Northern Pacific):—The Sub-Committee report under Appendix J, I think, speaks for itself. It is one of these continuing subjects, as the Chairman has said.

The Sub-Committee has found, in its attempt to simplify the work of the railroads and of the Commission and the contacts between the two bodies, many hurdles and one that we have felt was almost insurmountable. Fortunately, we now see a way over that hurdle and we have taken steps to accomplish it. If the Association will bear with us for another year perhaps we can accomplish something worth while.

It is with a great deal of regret that we have to continue this promise but we are working, and, in line with what Mr. Ford has said, we are hoping that we will be able to give some relief to some of the burdensome requirements of these reports.

With respect to Appendix K, it is impossible for the Sub-Committee to make any recommendations with regard to practice in establishing costs for ratemaking, taxes or similar proceedings, until the Commission has decided what it wants in the way of a classification. It will then be the object of the Sub-Committee to work out as simple a plan as is possible and which will obtain as near correct results as we feel are justifiable.

The question of costs of service has been the subject of a great deal of discussion, but those of us who are connected with the accounting work and valuation and some of us who are Engineers and working with the various carriers have found that everywhere we go on rate cases some economist or other expert springs a cost study on us. It is therefore believed by the Sub-Committee that instead of always being on the defensive in those instances we perhaps should be on the offensive occasionally. Therefore, I ask that the convention again bear with the Sub-Committee and let us carry on the study for another year. Thank you.

Vice-President John E. Armstrong:—Is there any question or discussion, gentlemen? If not, the report will be accepted as presented.

Chairman C. C. Haire:—That concludes the Committee's report, Mr. Chairman.

Vice-President John E. Armstrong:—Gentlemen, this Committee is carrying a very heavy assignment. The fact that they are reporting progress from time to time is not an indication that the Committee is not doing a job. I believe they are doing a job. It is part of their function to keep the Association advised of developments having to do with their assignment. The Committee is excused with the sincere thanks of the convention (Applause).

DISCUSSION ON WATERPROOFING OF RAILWAY STRUCTURES

(For Report, see pp. 273–283)

(Vice-President John E. Armstrong in the Chair.)

Mr. J. A. Lahmer (Missouri Pacific):—The report of this Committee is found in Bulletin 350, beginning on page 273. Of the four assignments, we are reporting on only one, the last, Specifications for Membrane Waterproofing of Concrete Work, Except Roofs of Buildings. These specifications were prepared by the Committee as a whole and I will therefore make the report. They are based on the specifications for waterproofing bridge decks which were adopted, I believe, six years ago. They have been broadened in order to include all concrete structures except roofs of buildings, and have been revised in accordance with developments that have taken place. They have been in course of preparation for several years and since this report was printed they have been placed in the hands of producers of waterproofing materials and also of representative contractors for the application of waterproofing. They have been so favorably received that, if there be no objection, the Committee would like to change its recommendation to read that the specifications be adopted and printed in the Manual.

There is one reservation or modification of that and that is with reference to the part of the specifications that relates to asphalt plank for protective covering. This is a comparatively recent development and the situation is changing very rapidly right now. If these are adopted, we expect to present revisions with reference to the asphalt plank next year.

The part relating to asphalt plank as now in the proposed specifications is taken from actual practice which has given satisfactory results. I presume you do not care to have the entire specifications read. If you wish, I could briefly point out the major differences between these and the ones that are in the Manual.

Vice-President John E. Armstrong:—Gentlemen, this report has been before you with the recommendation that it be received as information. Is there any objection to regarding these specifications as being presented for adoption and publication in the Manual?

Mr. J. C. Irwin (Boston & Albany):—I desire to protest as a matter of policy. It seems that this is the first time this has come before the members of the Association. The recommendation at first was to accept it as information. One who might be ready to accept it that way might not be ready to approve it for inclusion in the Manual. Some of these things, I think, require a little seasoning, a little study, a little more opportunity to discuss them. It is often better to bring them up the second year after asking for comment and then recommend them for the Manual. Therefore, I should dislike very much to see this material rushed into the Manual on this first report.

Vice-President John E. Armstrong:—Is there any further discussion on this point?

I think the Committee has done an excellent job in turning out a set of specifications which as stated by the Chairman seems to be so acceptable to those who have had occasion to study them. As the Chairman suggests, there are probably certain revisions that would have to be presented next year anyway, in connection with a portion of the specifications. As the specifications have not been before you as prospective Manual material at this time, I think Mr. Irwin is correct in his stand on the principle. Is there any other view?

Chairman J. A. Lahmer:—We accept that view. We have recognized it from the start. Our only thought was that so long as they seemed to have drawn no adverse criticism the Association might desire to have them made available for earlier use. We should be very glad to carry them over.

Vice-President John E. Armstrong:—The specifications will be available in the Proceedings during the coming year and I doubt if any serious difficulty will arise by their not being approved for inclusion in the Manual at the present time. As the Chairman concurs, the specifications will therefore be accepted as information for discussion during the coming year and will be presented later for adoption.

Chairman J. A. Lahmer:—The Committee has nothing further to report.

Mr. A. R. Wilson (Pennsylvania):—I would like to ask a question. On page 276, under Item 14, Treated Fabric, paragraph (e), referring to tensile strength, it speaks of the grab method. I am wondering if everybody understands what the grab method is, and whether there should be some reference in the specifications to show what it is. I assume it is the A.S.T.M. method.

Chairman J. A. Lahmer:—We looked it up but that was sometime ago. I am unable to give all the details, but my recollection is that it is a method prescribed by the A.S.T.M. Of course, we have covered that in another way, because in another paragraph we state that tests of all materials shall be made in accordance with the current methods recommended by the American Society for Testing Materials.

Mr. A. R. Wilson:—I overlooked that note. I wish to commend the Committee on the development of these specifications. On our railroad for several years we have been endeavoring to develop a plank that will meet our requirements. Our test department initiated a method of testing, which is entirely different from that outlined by this Committee. After receiving these specifications, I had a piece of plank made and tested according to our methods, and they report that these specifications will produce a satisfactory plank. I am very glad to find a specification for plank which can be generally used. As it is now, plank is purchased on price, without specifications.

Chairman J. A. Lahmer:—We appreciate your remarks. There are at least three or four other methods for testing plank that have come to our notice. Some of them seem to be more novel than anything else, but this one was taken from actual practice.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—Just one more point. I have had quite a bit of correspondence with Mr. Lahmer on some of these specifications. I note that the specification for asphalt for saturant on page 274 does include a specification for ductility at 40 degrees Fahr. On page 275, the specification for coal-tar pitch gives ductility only at 77 degrees Fahr. I would suggest, Mr. Lahmer, the advisability of including also in this specification covering ductility at 40 degrees Fahr., which, to my mind, is more important than the one at 77 degrees.

Chairman J. A. Lahmer:—Just as a matter of information and as a partial reply to Mr. Hirschthal, I would say that we consulted with what we considered were people who were well informed about both the coal-tar pitch and the asphalt, as well as all the other materials, and the weight of opinion as we developed it is that it is not necessary. However, we shall be glad to give the matter further consideration and try to answer the query more decisively.

Mr. B. R. Leffler (New York Central):—I should like to ask if the Committee has examined any service tests. By that I mean, how does that asphalt plank behave in actual service? It has been in use, now, for almost ten years. We ought to be able to know about some of the service test results.

Chairman J. A. Lahmer:—I am not sure but I think Mr. Leffler's estimate of the length of time it has been in service is rather too long. However, the difficulty, so far as that point is concerned, is that the making of the asphalt plank has developed so rapidly and so radically that of the kind now considered the best you would not find very long service tests. However, we are informed by people who have used this particular kind

of plank that it is behaving satisfactorily, but of course they say that the length of time covered by the service test is not yet sufficient to justify a final opinion.

For instance, elaborating the first part of my answer, originally asphalt plank was manufactured largely from refuse and waste materials, the odds and ends left over at roofing factories. It seemed to be pretty well received. By and by somebody, one of the Bridge Engineers, attempted to lay down certain characteristics that it should comply with. Then it went a little further. Now that it is getting down to a complete specification of what we want, and how much of each ingredient we want between certain limits, we have an entirely different plank from the one we had when asphalt plank was first used, and entirely different from the kind that is longest in service.

Mr. Meyer Hirschthal:—I can cite an instance of experience on length of service of the asphalt plank. In 1923 the Lackawanna developed a precast mastic waterproofing protection in the form of a block according to our specifications and used it on the East Orange improvement. Early in 1926 a representative of one of the asphalt plank manufacturers called to see me in connection with using his plank as a competitive product with the product that we had been using. At that time the product was made of new material, and the cost was prohibitive. I told that representative that under the conditions he could not compete with that, if the material was what he represented and the cost as he stated. The first use of the plank after that was the following year. That makes the service much less than ten years.

Vice-President John E. Armstrong:—Is there any further discussion? Gentlemen, this is the second report of this Committee and it is obvious that they are doing a job; a real job. We can excuse the Committee with the thanks of the Association (Applause).

DISCUSSION ON STANDARDIZATION

(For Report, see pp. 309-321)

(Vice-President John E. Armstrong in the Chair.)

Mr. J. C. Irwin (Boston & Albany):—The report of Committee XXVI—Standardization, is found in Bulletin 351 on page 309. The first assignment of this Committee is probably as important as any assignment to any committee, if the members of the Association take it to heart. It is to encourage the use of A.R.E.A. Recommended Practices. Your President this morning emphasized the value of the work done by our Committee and I wish to emphasize still further that if we are to get the benefit of the time and the skill of many men most experienced in various subjects who work through a period of years to develop material which is in the Manual, each member must do what he can to use the results so that all the railways of the country will have the benefit of it.

The Recommended Practices should establish themselves through their intrinsic merit, but if members of the Association neglect to use them, it sometimes may be due to their lack of realization of the value of uniformity in general practice. As has been pointed out in previous reports of this Committee, uniformity is of the greatest importance in matters which involve relations between railways and other interests and between two or more railways, they, in turn, having similar relations with other railways. That should be perfectly apparent.

This Committee has not issued questionnaires to determine the extent of the use of the Manual because we believe that it would not tend to extend the use of the Manual, and at the same time, if it were followed for all the material in the Manual, the returns would be so voluminous that it really could not be printed, and we question the value of it.

The work of the A.R.E.A. is recognized throughout this country and other countries, and an indication of the recognition of the A.R.E.A. is given by the National Directory of Specifications for 1932, issued by the Bureau of Standards, United States Department of Commerce, which contains one hundred and forty-eight references to A.R.E.A. Recommended Practices.

I wish to bring to the attention of the members the importance of their use of material in the Manual so far as they can use it, and still further, the importance of bringing to the attention of Chairmen of Committees any reasons they cannot use it. We shall never make progress in the use of the Manual if various members simply refrain from using it on account of some personal preference for something different, but this Committee wishes to ask the members who are not using material in the Manual so far as it might be used, to bring to the attention of Chairmen of Committees any reason for not using it. Let the Chairmen consider these reasons in their committee-work, and then let the Committee Chairmen bring them to the attention of the Committee on Standardization for further investigation.

The subjects deserving special attention are those in which uniform practice will effect material economy and those in which uniform practice will avoid disturbances in the relations between the railways and shippers, manufacturers of supplies, contractors and the public.

Members of the Association can also aid in the extension of uniform practice by seeing that the various departments of their railways other than Construction and Maintenance are impressed with the value of the Manual and, if possible, see that they are supplied with it or at least refer to it in connection with all matters on which this Association has taken action and has approved for the Manual. Again, if in the opinion of any member of the Association a situation develops which indicates that in order to secure more general use of Recommended Practice it should be revised, the member should call the situation to the attention of the Chairman of the Committee concerned so that the point involved may be considered in connection with revision of the Manual.

On page 310 you will find reference to the American Standards Association, as another thing to take note of and not a thing to be abstracted here. For those not thoroughly familiar with the work of the American Standards Association and the relations of the American Railway Association to it, it is well to read that statement.

The second part of the assignment of Subject 1 of this Committee is to consider subjects for recommendation to the Board of Direction for sponsoring as projects for national standardization. That I shall take up in a few minutes. The second subject is to maintain contact with standardization bodies and keep the Association informed on important matters developed by such contact. In order to have closer cooperation with other standardization bodies, you recall that last year we arranged a meeting by this Committee, which is composed of the Chairmen of all Committees, with representatives of the Bureau of Standards at Washington, at the headquarters of the Bureau of Standards. This year this Committee had a meeting with representatives of the American Standards Association in New York, at which various members of the staff of the A.S.A. addressed the members of this Committee on the activities of the American Standards Association.

On page 313 you will find a revision of the representation of the A.R.A. in the A.S.A., that is, the revision in the assignment of representatives to committees of the American Standards Association on subjects which eventually will come up for national standardization through the American Standards Association.

On page 314 there is reference to the inch-millimeter conversion for industrial use. That is a matter which does not concern us very deeply because, while it affects the

Committee on Lumber Standards with headquarters in Washington, on which we are represented by Mr. W. E. Hawley. This is a case of encouraging the work of the various members who are interested in bringing about an American Standard.

One of the most important standardization projects that we have been working on is being handled by the Joint Committee on Grade Crossing Protection, of which Mr. Frank Ringer is the Chairman.

In order that the Association would have the benefit of the report on progress that is being made in this connection, Mr. Ringer furnished us with a statement which is authorized and which is printed on page 318.

Under Simplified Practice, we are cutting down the number of sizes, types and kinds, and are getting down to a smaller number for standardization. This year Simplified Practice Recommendation No. 17–31, Forged Tools, issued January 4, 1932, includes A.R.E.A. Track Tools as adopted for the Manual in 1930. In this Simplified Practice Recommendation, the variety of forged tool items has been reduced from 665 to 431 and the eye sizes from 120 to 11.

On page 319 is found reference to the work of the Canadian Engineering Standards Association. In Canada the standardization work is done through that association, as well as the Simplified Practice Work, and this Committee, in order to extend its contacts with other standardizing bodies and be able to report to this Association, has planned a meeting with the Canadian Engineering Standards Association, the C.E.S.A. Their Secretary has provided us with some information as to the progress in the C.E.S.A. during the past year, and one of the most important activities is in connection with the Imperial Conference held at Ottawa last summer, referred to on page 320, in which the subject of Empire Standards was very extensively discussed, of course mainly in connection with encouraging their Empire trade. It is a thing we in this country should keep in touch with for in a number of these things we are tending toward international standardization and contact with the Canadian organization will help in this respect.

On page 321 you will find a statement of the standards approved by the American Standards Association during the year September 1, 1931 to September 1, 1932.

Mr. Chairman, that completes the report of the Committee.

Vice-President John E. Armstrong:—Gentlemen, is there any discussion? Are there any questions you want to ask? Your Committee on Standardization is doing a very real work, a very important work. In conversation with Chairman Irwin recently (I cannot quote the conversation verbatim) he expressed himself something like this: Standardization is a thing that is with us. It is happening. It is going to continue to happen. We have the option of going along with it and being part of it, sharing in it, or standing aside and watching the procession go by. We cannot afford to stand aside and let the procession go by, gentlemen, and this Committee is keeping us right up with the band wagon.

The Committee has done an excellent job and is excused with the thanks of the Association (Applause).

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On page 321 you will find a statement of the standards approved by the American Standards Association during the year September 1, 1931 to September 1, 1932.

Mr. Chairman, that completes the report of the Committee.

Vice-President John E. Armstrong:—Gentlemen, is there any discussion? Are there any questions you want to ask? Your Committee on Standardization is doing a very real work, a very important work. In conversation with Chairman Irwin recently (I cannot quote the conversation verbatim) he expressed himself something like this: Standardization is a thing that is with us. It is happening. It is going to continue to happen. We have the option of going along with it and being part of it, sharing in it, or standing aside and watching the procession go by. We cannot afford to stand aside and let the procession go by, gentlemen, and this Committee is keeping us right up with the band wagon.

The Committee has done an excellent job and is excused with the thanks of the Association (Applause).

DISCUSSION ON MAINTENANCE OF WAY WORK EQUIPMENT

(For Report, see pp. 355–420)

Mr. C. R. Knowles (Illinois Central): The report of Committee XXVII—Maintenance of Way Work Equipment, appears on page 355 of Bulletin 351.

The Committee has continued its study of Section Duty Motor Car Parts and Accessories, and offers for inclusion in the Manual a series of specifications covering fuel line connections, size of cord belts, gasoline tanks, brake shoes and ignition systems.

A report is presented on Types of Snow-Melting Devices as an Aid in Facilitating Train Operation and Reducing Maintenance Cost.

A report is offered on Use and Adaptability of Track Type Tractors in Maintenance of Way Work.

A report on Organization for Use and Maintenance of Tie Tamping Machines, Air and Electric, is also presented.

In addition to this, there is a report on Tie Adzing, Scoring and Boring Machines, and one on the Use of Ditching-Spreaders in maintenance of way work.

The first report submitted by the Committee is on page 356. I will ask Mr. Westcott, Chairman of the Sub-Committee, to present the report.

Mr. G. R. Westcott (Missouri Pacific):—In previous years the Sub-Committee has called to the attention of the convention a number of items that we believed might be made standard in the matter of section duty motor car parts and accessories. A number of these have been adopted by the convention in past years, and, as Mr. Knowles has called to your attention, we are presenting today five other such items. I want to comment just briefly on each one of these items.

The first one covers details of gasoline line connections. If you recall, that subject was up last year and at that time there was some criticism on the floor of the convention as to the language that we had used in describing the thread of the connections. In order to clarify this matter (and I may say that the criticism was prehaps just), we have revised the drawing, showing reference to the American Standards Association thread rather than to the thread of the Society of Automotive Engineers, as given last year.

In connection with belts for section duty motor cars, apparently it is not possible to adopt a definite standard. The Committee has, however, expressed what in their judgment is desirable, both as to width and to length.

In the matter of gasoline tanks, the Committee has been governed largely by the experience of the automotive industry, recommending a tank of terneplate and specifying, to the degree that we felt reasonable, the details of construction. It is not possible to adopt size nor shape, apparently, except in a very general way.

In the matter of brake blocks, for a good many years a simple block of oak or other hard wood was used on motor cars as a brake block, and it was assumed that it was the best block available. Within the last year or so there have been some tests made by several railroads showing conclusively that the ordinary wood block, while it functions fairly well in dry weather, is outclassed entirely by a soft iron block when the rail or the wheel is wet. The Committee therefore recommends the use of a soft iron facing on the wood block as a means of quicker stopping and greater safety.

On the fifth item, we have indicated a one-half inch pipe thread for spark plugs. Our thought in this was that a spark plug of that thread is admirably suited for the use of the motor car and is not commonly used in automobile service. That was not true in the days of the old Model T Ford but it is true now. We felt that the half-inch pipe thread plug would furnish everything that we needed and would prevent, perhaps,

pilferage that might result if we were to adopt some type of plug more commonly used in the automotive industry.

Those are the recommendations and we have given you the reasons for bringing them to you. They are submitted to you for your consideration and are recommended for inclusion in the Manual. I so move.

Mr. W. A. Radspinner (Chesapeake & Ohio):—I have had some correspondence with some of the members of the Committee in regard to the recommended nut they use to fasten the fuel line to the gasoline tank. The shocks to the gasoline pipe on the automobile can hardly be compared with that on the rail motor car.

Mr. Constance, a member of your Committee, made samples of three types of units including the proposed standard and assembled them on a pipe line with packing in place. These samples were placed before the Engineer of Maintenance of Way. I told him to pull the pipe out of the standard unit and then put it back. He could not put it back without destroying the packing in the unit. The Committee claims it can be repacked in that case by felt or something similar and this is what I will not agree to because such packing will leak. I have found this out from actual experience through our inspection service.

We took another sample, a sketch of which I sent the Committee, to which a collar has been fitted and sweated to the pipe and packed it with felt and it has not leaked and the pipe has not cracked or broken at the unit.

When the fuel line is covered with flammable fuel and the unit is leaking a fire will follow the line to the unit where the the nipple to which the unit is attached is soldered to the tank. The solder soon melts and outpours a flaming fuel which soon consumes the whole car.

Another thing that I do not see specified here is the kind of valve that should be used at the tank. Some of the manufacturers use a two-way valve or plug. When it is turned one way it lets the fuel out for use either as priming or for such other purposes as may be necessary. Turned the other way, it allows the fuel to go into the pipe line.

The springs holding the plug in place are often weak allowing fuel to drip and if the plug is removed and replaced with dirt or lint on it there is sure to be a leak because it depends on the taper to make a joint. This valve should be of a positive type with an approved valve seat.

Mr. G. R. Westcott:—I should like to say, in reply to Mr. Radspinner's comment, that this matter was quite thoroughly gone into with the men who are actually maintaining the motor cars on the various railroads represented on our Committee. It was practically the unanimous recommendation of those men that a type of coupling, which in case of emergency can be repacked with waste or your pocket handkerchief, if necessary, was the most desirable type from the standpoint of field maintenance. The cork packed coupling is of this type. A copper pipe with a shoulder brazed on it, as suggested by Mr. Radspinner, would probably be more nearly 100 per cent leakproof under certain circumstances, but the man who maintains the car in the field is rather up against it with that sort of device if something actually gives way.

With reference to the matter of cutoff valve, I would say that this does not come within the scope of the present report. We are not through talking about parts and accessories for motor cars, however, and I can pledge Mr. Radspinner that in our work for next year we will give attention to this.

Mr. W. A. Radspinner:—It is the failure to hold the pipe in place with the cork packing. When you realize that when trouble occurs the first thing they do is pull down that fuel pipe and if the nut comes off the pipe you will see that they cannot

get it back again with that particular packing. On the matter of the pipe with the collar that I suggested, the collar is fastened to the pipe so the nut cannot come off. We have had one in service for six months and more on the Chesapeake & Ohio and we have not had any cracking off of pipes or any leakage at the nut.

The President:—Are you ready to vote?

(The motion was put to vote and carried).

Chairman C. R. Knowles:—The motion was to include Items 1 to 5, with the diagram, in the Manual.

The next report appears on page 358 and covers Types of Snow-Melting Devices as an Aid in Facilitating Train Operation and Reducing Maintenance Cost." Mr. Hewes, Chairman of the Sub-Committee, will present the report.

Mr. F. S. Hewes (Santa Fe):—This report is found on pages 358 to 383 inclusive, of Bulletin 351. It covers all information available up to the date of printing of this Bulletin. The first two pages are general, followed by several pages of actual benefits secured by using snow-melting devices.

Pages 362 to 379 show information on every type of device that the Committee could secure such information on. Table 1 covers results of the canvass and includes 86 railroads. The symbol X denotes the use of a type by the designated roads. The Bibliography on pages 381 to 383 includes 33 articles reviewed. A brief has been made of each one, amounting in all to 44 letter-size typewritten sheets, and negatives have been supplied to Secretary Fritch so that those interested may arrange for copies.

The Committee recommends that this report be received as information and the subject continued.

The President:—Is there any question? Any discussion? If there is no objection, it will be so received.

Chairman C. R. Knowles:—With your permission, I will pass over the Sub-Committee report No. 5 leaving it for the last, inasmuch as we have a motion picture accompanying the report, and at this time I will take up the report of the Sub-Committee on Organization for Use and Maintenance of Tie Tamping Machines—Air and Electric, which appears on page 409. Mr. Holt, Chairman of the Sub-Committee, will present the report.

Mr. L. B. Holt (New York Central):—This report amplifies the report of this same Sub-Committee which appeared in the Bulletin of January, 1931, Vol. 32, No. 333. More specific comment is made regarding electric tamping outfits, and the diagrams showing the suggested pipe arrangements for pneumatic outfits have been modified by changing the reference to hose couplings and fittings which in the older diagrams might have been construed to mean that the fittings produced by one manufacturer only could be employed. This report is submitted as information.

The President:—Is there any question? If not, the report will be received as information.

Chairman C. R. Knowles:—The report of the Sub-Committee on Tie Adzing, Scoring and Boring Machines appears on page 413. As the Chairman of that Sub-Committee is not present, I will merely state that the report includes a discussion of tie adzing, scoring and boring machines, and confines the discussion to the portable or self-propelling type of machine as used in the field. The report refers chiefly to adzing and scoring machines; the subject of boring machines is to be taken up later on.

This report is submitted as information with the recommendation that the subject be continued.

The President:—If there is no objection, it will be so received.

Chairman C. R. Knowles:—The report of Sub-Committee on the Use of Ditching-Spreaders appears on page 416. This report includes a brief introduction and history of the use and development of spreaders, and also a survey covering the use and application of this machine on railroads.

The report is presented as information.

The President:—Any discussion? If there is no question, it will be so received.

Chairman C. R. Knowles:—We will now return to page 384, the report of the Sub-Committee on Use and Adaptability of Track Type Tractors in Maintenance of Way Work. This report includes a general discription of the track type tractor as distinguished from the wheel type. It also covers a discussion of the auxiliary equipment adapted to the track type, the classes of work performed, examples of specific use, including cost studies of various classes of maintenance of way work performed by tractors and auxiliary equipment.

In connection with this report, we have a sound motion picture which we would like to present at this time.

(Showing of sound motion picture illustrating use of track type tractor and auxiliary equipment.)

Chairman C. R. Knowles:—Before concluding the report of the Committee I want to take this opportunity of expressing the thanks of the Committee for the cooperation of Mr. O. E. Andren, of the Caterpillar Tractor Company, and of the various railroads in the preparation of this film. That concludes the report.

The President:—Are there any questions you would like to ask this Committee? This Committee is really one of the youngest committees of the Association. They have grown out of the freshman class very quickly. In fact, they have been promoted to the status of a standing committee as quickly as any committee we have. They are doing very good work and I want to compliment the Chairman for the fine work he did in presenting his report. It expedited matters very much. The Committee is excused with the thanks of the Association (Applause).

DISCUSSION ON STRESSES IN RAILROAD TRACK

(For Report, see page 703)

Dr. A. N. Talbot (University of Illinois):—The Committee on Stresses in Railroad Track presents only a brief report. It is printed in Bulletin 354, February 1933. More time has been required to put the experimental data into form for publication and to formulate the interpretations and findings than had been expected. Some time ago 275 mimeographed pages of manuscript and 70 blueprints went out to the Committee for its study and consideration. More is in preparation. Yesterday at its meeting the Committee struggled with the mass of material and made progress with its consideration, but further time is needed to complete the writing and to finish off the report in final form.

Under the circumstances President Neubert has asked me to talk about a few of the matters dealt with in the report. Several topics will be treated, necessarily rather briefly and sketchily, and also very disconnectedly.

Tests on a Continuous Rail-Joint.—Laboratory tests on Continuous rail-joints loaded as beams give information on the stresses and movements in such bars. Fig. 1 shows a section of the headfree Continuous bar for 130-lb. P.S. rail and the measured stresses over its midsection at bolt tensions of 15,000 lb. and 2,000 lb. Attention is called to the variation in stress over the reflexed flange at the bottom. At the extreme outer edge of the flange (gage line 14) the measured stress is about 23,000 lb. per sq. in. and at the inner edge under the middle of the rail (gage line 17) it is 10,000

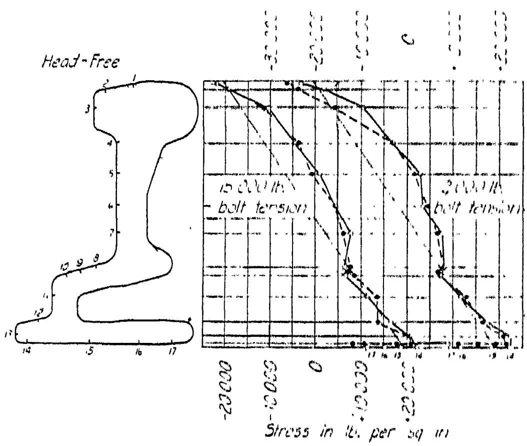

FIG. 1.—Section of Bar and Observed Stresses at Mid-Section—Head-Free Continuous Rail-Joint.

lb. per sq. in., although the gage lines are at the same distance below the nominal neutral axis. It was found that the deflection along a line at the inner edge for the length of the bar differs considerably from that at the outer edge. This and the variation of stresses along the bottom and other matters brought out in the test show that the section does not act integrally as is generally expected of beams, and that the reflexed flange is not fully efficient in resisting flexure. Regardless of this, the reflexed flange offers an opportunity to increase the section of the bar, and the section as a whole perhaps has little or no more loss in moment-resisting efficiency than has the angle bar

form, but it should be said that the deflection of the joint was relatively greater than that found for the angle bar—the section shown is the headfree bar. The stress distribution found in the reflexed flange for the head-bearing bar is quite similar to that shown here.

The vertical and lateral movement of the bar with reference to the rail is of interest. In Fig. 2 the left half of the diagram (both top and bottom) gives movements of the head-bearing Continuous bars and the right half movements of the headfree Continuous bars with respect to the rail upon application of load. The upper part gives the vertical movement between bar and rail head. It will be seen that with 15,000 lb. bolt tension the vertical movement of the head-bearing bar at its middle and ends is slight and that the movement of the headfree bar is much greater. With 2,000 lb. bolt tension the vertical movement of the head-bearing bar is somewhat larger at mid-length of the bar than was found with the high tension and considerably greater at the ends, amounting to .010 and .018 in., the bar moving down from the rail head—values which may seem small but are really significant. With 2,000 lb. bolt tension the head-

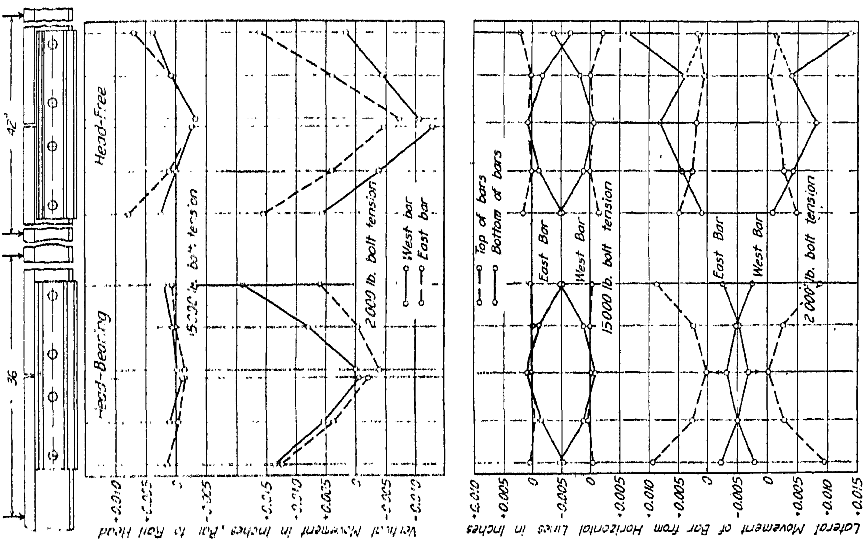

FIG. 2.—Vertical and Lateral Movement Between Bar and Rail—Head-Bearing and Head-Free Continuous Rail-Joints.

free bar (right) has a similar downward movement (away from the head) at the ends, and at mid-length a movement of the bar toward the head at the end of the rails amounting to .012 in. in one bar. In the lower part of the figure, with 15,000 lb. bolt tension the lateral movement of the top of the bar (dashed line) away from the rail is slight in the head-bearing bar but it is noticeable in the headfree bar. The bottom of the bar (full line) moves slightly outwardly from the rail at mid-length and the inward movement of the bottom of the bar at its ends is very marked. With 2,000 lb. bolt tension, at mid-length of the head-bearing bar the top remains stationary and the bottom moves inward; at the ends the bottom of the bar moves inward considerably and the top of the bar moves outward from the rail markedly, reaching .010 in. The headfree bar (2,000 lb. bolt tension) at middle has a marked outward movement at both top and bottom, and at the ends the movement is also outward at both top and bottom.

It is evident from both the vertical and the lateral movements of the headfree bars that upon applying load there is a change in the position of the top contact bearing at mid-length with respect to the fillet of the railhead, a condition that is much more marked in the case of low bolt tension. These movements are corroborated by the changes in bolt tension observed with the headfree joint; with the low bolt tension the tension in the inner bolts of the headfree bar increases by 2,000 lb. or more upon application of load, and the tension in the outer bolts increases 8,000 lb.; with 15,000 lb. bolt tension no change in tension is produced in the inner bolts with application of load but the tension in the end bolts increases 4,000 lb., all of which is different from the action with the head-bearing bars. It is evident from the tests that for the headfree bars it is especially important that all bolts be kept tight.

Lateral Springing of Joint Bars When Nuts Are Wrenched Up.—It of course is apparent that the mere stretch of a bolt does not furnish any considerable protection against the lateral movement and wear of bars in maintaining tightness—a bolt tension of 20,000 lb. corresponds to a stretch in the bolt of about .005 in. Something more is needed to act against lateral movements with the natural bending and twisting of the bars under load. It may be expected that the flexure of the bars longitudinally and perhaps vertically in the tightening of the bolts provides through the springing action a recourse against loss of tension considerably greater than will be obtained by the stretch of the bolts. In the tests reported in the following three figures the joints were tested without spring washers. The joints include angle bars for 127-lb. N.Y.C. rail, angle bars for 130-lb. P.S. rail, Continuous bars for 130-lb. P.S. rail and the so-called Santa Fe symmetrical bars for 130-lb. R.E. rail.

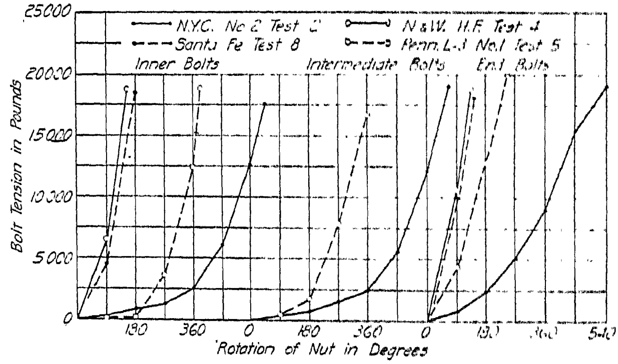

FIG. 3.—Rotation of Nut and Corresponding Bolt Tension for Four Forms of Joint Bars.

In Fig. 3 the amount of rotation of nut is plotted horizontally and represents amount of movement of nut along the bolt—one-half turn (a rotation of 180°) equals .06 in. of such movement. Preliminary to the observations of a test the bolts were tightened to 20,000 lb. and the load on the joint was applied five times—then the bolt tension was released and the nuts were turned up snugly without the bars leaving their close contact to the rail. The nuts were then wrenched up by increments of one-quarter turn (90°), and the magnitude of the corresponding bolt tensions are recorded by the vertical scale of the figure for four kinds of bars, two of them short and two long. It will be noted that to reach a tension of 3,000 or 5,000 lb. the nuts were given one-quarter to 1 turn (nut movement along the bolt of .03 to .12 in.), while to go from

5,000 to 20,000 lb. bolt tension (the range of desirable bolt tension) required a further rotation of only one-quarter to ½ turn (.03 to .06 in. of nut movement), an effective provision for each bar amounting to, say, 5 to 10 times that obtained from the stretch of bolt in maintaining bolt tension, or more.

A more detailed test was made with the Pennsylvania 38½ in. angle bars. In this test made after preliminary loadings like those just described, the bolt tensions were measured after each increment of wrenching and before a load was applied and also after the release of the fifth application of load. After a tension of 20,000 lb. had been reached, the nuts were unwrenched by increments and as before the same load was applied five times at each unwrenching. Fig. 4 shows the magnitude of the bolt tension.

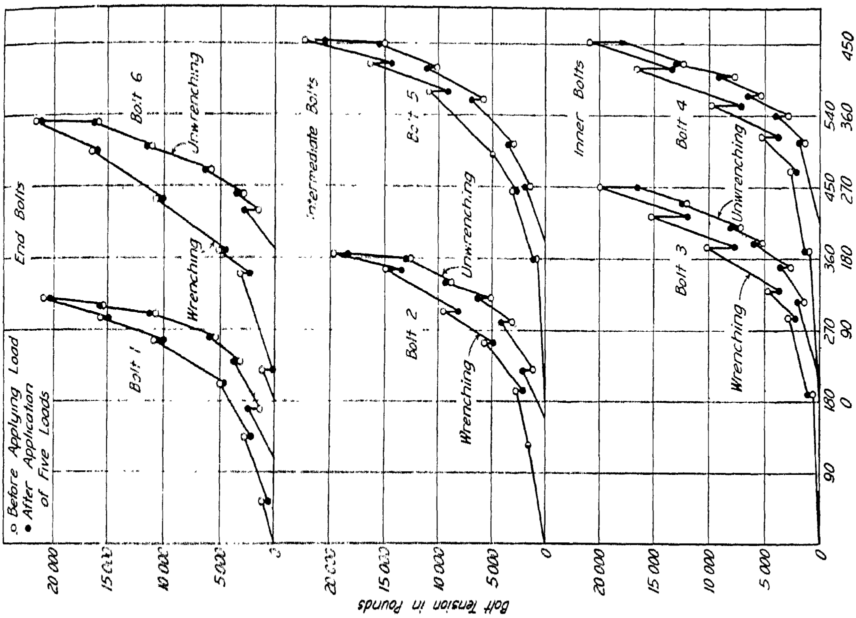

FIG. 4.—Rotation of Nut and Corresponding Bolt Tension Before and After Five Applications of Load.

For each position of the nut the open points represent the tension before the first load was applied and the solid points the values after the fifth load was applied. It will be noted that after an increment of wrenching the tension drops off with the repetitions of load and during an unwrenching the tension increases with the five applications of load—the reason is apparent. The amount of change that occurs at a single application decreases with each application, and five repetitions nearly exhaust the effect.

In Fig. 5 the results of the preceding test have been summarized, only the values of the tension left in the bolt after application of load for a given wrenching are shown. The curve for unwrenching is the significant part of the diagram. It will be noted that the upper part of the curve is very steep and gives less travel for a given change in bolt tension than that below. It is apparent too that at tensions above 20,000 lb. the useful travel will become so small as to give little assistance in maintaining bolt tension. For the bars used the movement of nut between tensions of 20,000 and 5,000 lb. in unwrenching amounted to 6 to 12 times the stretch of the bolt.

Although the top and bottom of the bar did not move inwardly as much as the movement of the nut, most of the spring would be available in maintaining the position of the bar with respect to the rail. Altogether these tests suggest that the springing action of the bars itself helps in maintaining bolt tension.

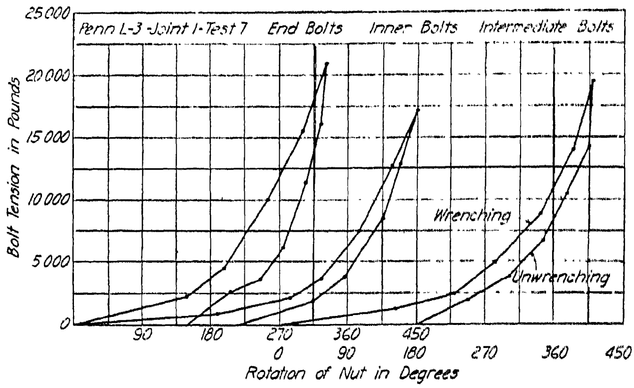

FIG. 5.—Summarized Values for Rotation of Nut and Corresponding Bolt Tension After Five Applications of Load.

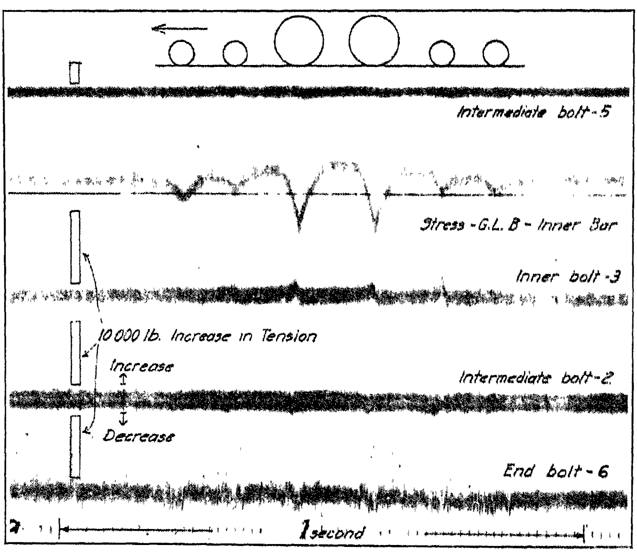

FIG. 6.—Film Record of Stresses at Top and Bottom of Bar.

It may be remarked that the laboratory and field tests made confirm the finding in the Fifth Progress Report that for the symmetrical type of bar a minimum tension of 5,000 lb. may be expected to give satisfactory conditions for both vertical and lateral bending on straight track and light curves, with a corresponding minimum tension of 10,000 lb. for angle bars. The upper limit of useful tension for both forms may be considered to be 20,000 lb. These values apply to track conditions after the bars have been worked into place and have approached a fairly stable position. It

follows from the tests that the wrenching of bolts to 40,000 or 50,000 lb., as is sometimes practiced, gives little useful result in maintaining bolt tension, and it may be productive of ill effects in other ways.

Tests at Speed.—We have all been wondering about the effect of speed upon stresses in joints. Fig. 6 shows a sample film record for gage lines at the top and the bottom of the angle bars at mid-length in tests on the Pennsylvania Railroad for a speed of 45 miles per hour. At the top is a bolt tension record, which shows practically no change in tension during the passage of the locomotive. The scale for a stress of 10,000 lb. per sq. in. is given at the left of the three stress records—the greatest stress recorded here is 22,000 lb. per sq. in. Some tests were made at 90 miles per hour and a number at 5, 45, and 70 miles per hour. Generally three runs or more were made at a given speed—in a few tests only two.

From the stress data of the tests, the bending moment at mid-section of the two bars was calculated. Since the moments in the several joints tested naturally differ considerably because of differences in conditions of rail support and fit of bars, their values have been expressed in terms of the average moment in the full rail under static loading as more readily giving comparisons of effect of speed. In Table 1 the value of the joint moment ratio for test *a* in the first line means that the average moment developed in the joint bars at mid-section for three or four runs at 5 miles per hour is .61 of the average moment found in the full rail with static loading—then reading across the table for the same joint, a value of .63 at 45 miles per hour, .65 at 70 miles per hour, and .65 at 90 miles per hour—almost no change in stress or moment in the joint bars for the several speeds. It will be noted that the increase with speed shown in the table is generally small. In some tests there is a decrease, as in test *i*. In test *b*, having an increase from the low value of .41 at 5 miles per hour to .68 at 90 miles per hour, the value at the high speed may be considered a moderate magnitude. The moment corresponding to the highest ratio in the table (.93) is of course less than the moment developed in full rail under static loading.

It should be noted that these tests were made on different joints, with differences in bolt tension, and with bars changed from one joint location to another and even with bars shortened to 24 in., and of course with diverse conditions of tie support. The joint in test *a* (38½-in. angle bars) had been undisturbed for several months under heavy traffic and had an average bolt tension of 29,000 lb. In test *b* (the same joint) the average bolt tension had been decreased to 2000 lb. and a .005 in. thickness gage could be inserted for 3 and 8 in. at the two ends of the bars and 2 to 6 in. at their middle. In test *c* the same bars had been sawed to a length of 24 in. and re-installed with a bolt tension of 28,000 lb. Tests *d* and *e* were made at the same joint location with 38½-in. bars taken from another joint location and bolt tensions of 14,000 and 12,000 lb. The joint in test *f* (joint location 5) had remained undisturbed under heavy traffic for several months and the bolt tension was 14,000 lb. The bars of test *g* were laterally deformed and had been installed in joint location 1 only a few days with a bolt tension of 12,000 lb. In tests *h* and *i* the bars from test *g* had been installed a short time at joint location 3 with bolt tensions of 23,000 lb. and 13,000 lb. respectively. Test *j* was made on track No. 1 on a joint with 38½-in. bars and an average bolt tension of 2000 lb., a track with large traffic not in as good condition as track No. 4, where most of the tests were made. The joint location of test *k* was on track No. 4 away from the other test locations and the joint had not been disturbed for a long time. The bars were 24-in. angle bars and the bolt tension averaged 6000 lb.

Part of the variation in values at a given joint doubtless is caused by variation in wheel load at the joint in one or more individual runs by transfer to the other wheel

on the same axle or to other wheels on the same rail. Altogether the effect of speed on the stresses in the joints is apparently not greater than the effect on the rail itself. With the electric locomotive used there is no great increase in stress and moment with increase in speed. It should be noted that the electric locomotive used gives little dynamic augment, and that with a steam locomotive the dynamic augment for the drivers will give a corresponding increase in stresses in the joint, as it will also in stresses in the rail.

Some speculation has been indulged in on the effect of speed on changes in bolt tension during the passage of the wheels of a train. In Fig. 7 the one record of bending stress at a gage line on the upper part of the angle bar (the record having peaks directly below the wheels), enables us to fix the position of the passing wheel loads with respect to the record of the tension of the four bolts shown. At the left the scales give the change that would be necessary to record an increase of 10,000 lb. bolt tension. The actual changes in magnitude of the bolt tension on the records shown are small, 1000 lb. increase in end bolts and a similar decrease in inner bolts. In all the tests at the various speeds up to 70 miles per hour the changes in tension were relatively small, perhaps generally 500 to 2000 lb. and in a few cases 3000 lb., values which are comparable with those found in statical laboratory tests. The sign of the change in tension, whether positive or negative, was generally similar to that found in static tests in the laboratory. The conclusion from the tests is that the magnitude of the changes in bolt tension during the passage of a train is not of great importance. It is to be expected that an even smaller change in magnitude will be found with symmetrical bars, since they do not have the same degree of tendency to swing inward at the middle and outward at the ends as have the angle bars.

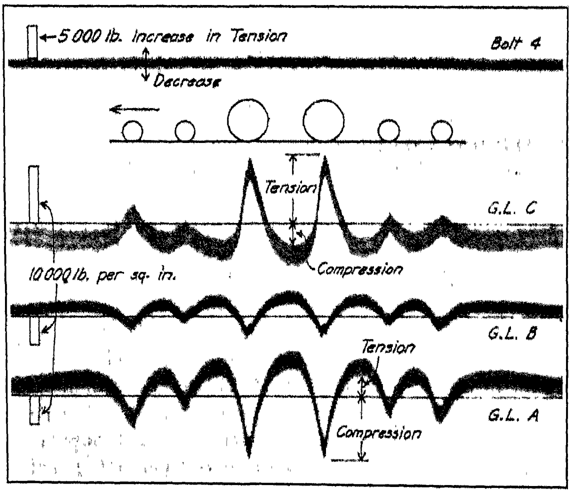

Fig. 7.—Film Record of Changes in Bolt Tension.

Variability in Track.—A year ago I presented to you information relating to the variability in track, in what is called heavy, high-grade track, stiffly ballasted track, in an effort to illustrate some of the defects and disadvantages that have become more marked by increasing the size of rail and especially by the great increase in the thickness and stiffness of ballast foundation. The data showed marked lateral bending of rail

from point to point and tie to tie, first inwardly of the track and then outwardly, quickly changing from tie to tie, the stress at one edge of base of rail sometimes being three times the average stress along the track, all for centrally applied loads. The data showed large changes in the mean stress in base of rail, ranging from three-tenths of the average stress along the track to 1.6 times the average stress, all for static loading. The tests showed extreme variations in the division of load carried by adjacent ties, varying from zero to 2.6 times the average share of load. Also, the bearing of rail on tie-plate and of tie-plate on tie was found to be irregular and uneven—sometimes the centroid of load applied by the rail was near one edge and sometimes near the other edge. The adzing for the tie-plate was not regular. A gage the thickness of a sheet of paper could be placed under the tie-plate over one portion of the bearing area when the rail was loaded, even the edge of a shovel or the thickness of a knife blade, and adjacent tie-plates were far from being in the same plane. To bring these conditions to your mind again, it seems well to show here two of the figures given last year and to follow with other figures representing vertical and lateral bending moments from point to point. Results of tests on track A will be given first, followed by results of tests on track B.

In Fig. 8 is shown the play between rail and tie bed in one location along track A as found from pull-up and push-down tests. The variation in play at nearby points before getting a firm support for the rail ranges from nothing to .18 in. Surely the rail

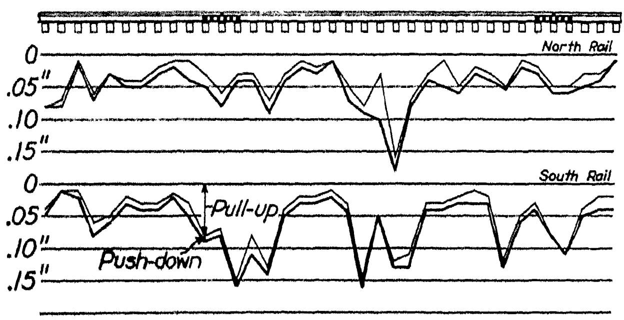

FIG. 8.—Play Between Rail and Tie Bed.

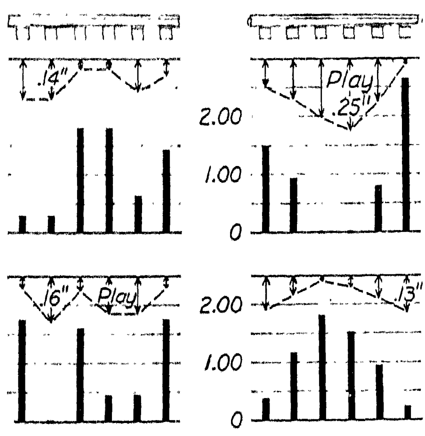

FIG. 9.—Variation in Tie Loads.

will not be able to bend to give even bearing on adjacent ties. Some ties will carry little, others much, perhaps more than they should. The stresses in rail at places will be far greater than normal. What would a track engineer think of embedding ties in a concrete base and leaving such variability as this in the levels of the rail-bearings over the ties? And yet the stiffness of an old consolidated broken-stone ballast foundation on an established roadbed approaches that of concrete and the effects of unevenness and irregularities are much the same. Should not the care given to the surfacing be such as to remedy some of the defects?

Fig. 9 showing variations in tie loads was given a year ago. Tie loads on ties in the same group varying from zero load to 2.6 times the average or expected load are noted. Similar conditions are to be found on much so-called high-grade track. Both ties and ballast are mistreated. The extra cost of greater uniformity is not large in comparison with the cost of rail and substructure. It is the maintenance methods that are at fault.

In Fig. 10 are shown the values of the vertical bending moment in 130-lb. rail at the rear wheel when the car is moved two tie spaces at a time along track A on which the tests referred to above were made. The magnitudes of course are proportional to

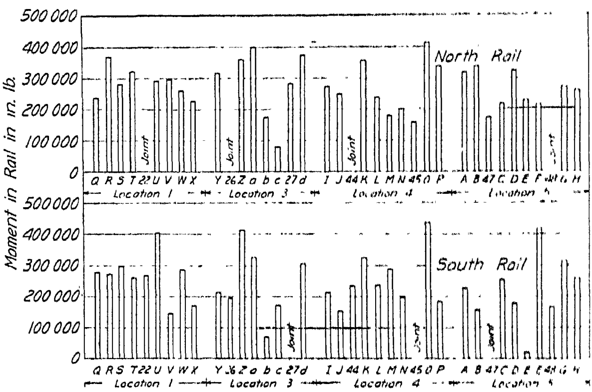

FIG. 10.—Vertical Bending Moment in 130-lb. Rail at Rear Wheel as Moved Along Track—Track A.

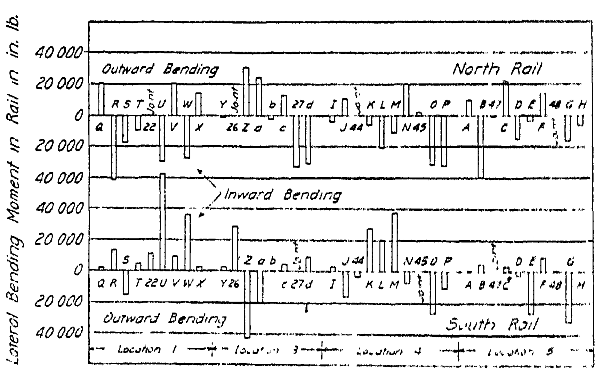

FIG. 11.—Lateral Bending Moment in 130-lb. Rail at Rear Wheel as Moved Along Track—Track A.

the mean stress in base of rail. The moments range from 20,000 to 440,000 in.-lb., with an average of 280,000 in.-lb. The variation in moment is due principally to the variations in the tie pressures just referred to and to the moment arm of these reactions. Note the marked changes in value from point to point along the track.

The foregoing figure is based on the mean of the stresses at the two edges of base of rail—for Fig. 11 the difference in stress at the two edges is used to determine the lateral bending moment in the rail at the same spots, and the magnitudes of the lateral moments are shown. Note the lateral bending of the rail inward and outward and the varying magnitudes, which of course involve corresponding twisting. The magnitude of the lateral bending moments may not be troublesome for the 130-lb. rail, but the effect on the ties and ballast bed and on maintenance is not to be measured by the stresses in this rail.

In Fig. 12 are shown the vertical bending moments in the 110-lb. rail at the rear wheel as the car is spotted at every second tie space along track B of another railroad. The load is somewhat lighter, 26,500 lb. per wheel instead of 30,000 lb. The track is well and deeply ballasted. The stretches at locations 1, 2 and 3 have hard limestone ballast, well compacted, and the track substructure is very stiff—the stiffest we have tested. The stretch at location 4 has flint gravel ballast and is less stiff, though this substructure has more than average stiffness. Except for five low values, the moments in rail on the very stiff ballast (locations 1, 2 and 3) differ from the average moment by an average variation of only 17 per cent, and the variation on the gravel ballast (location 4) is even smaller.

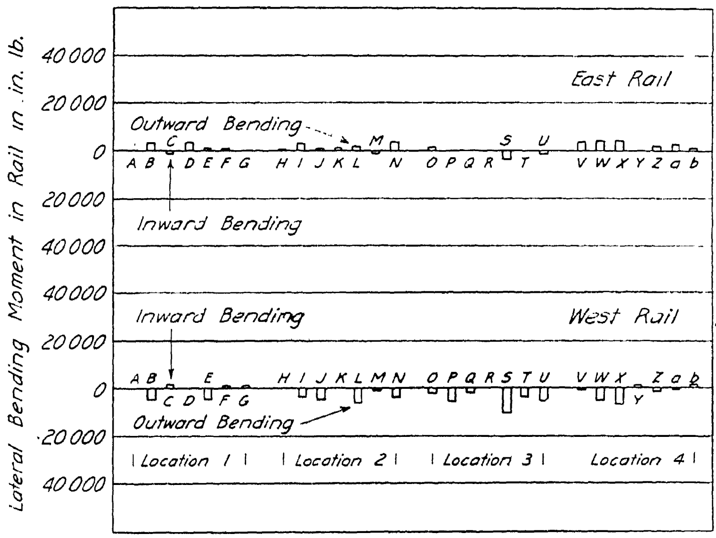

FIG. 12.—Vertical Bending Moment in 110-lb. Rail at Rear Wheel as Car is Moved Along Track—Track B.

The magnitudes of the lateral bending moments in the 110-lb. rail of track B are plotted in Fig. 13. The values are given for the points for which the vertical bending moments in the last figure were obtained. It is seen that the values of these lateral bending moments are remarkably small. At the 52 places measured, the average of the numerical values of the lateral bending moment in the rail is only 1.4 per cent of the average vertical bending moment, and the maximum lateral moment is 5 per cent.

In considering this comparison it should be remembered that the section modulus with respect to the vertical axis is .19 of that with respect to the horizontal axis. The lateral bending due to static loading is very small on this track.

In the GEO track on which the last tests were made (track B) the ties were preadzed and prebored in such a way as to make full and even bearing of tie-plate on tie and to bring the upper bearing surfaces of the tie-plates into the same plane from tie to tie along the track, with a further chance for slight adjustment by means of the

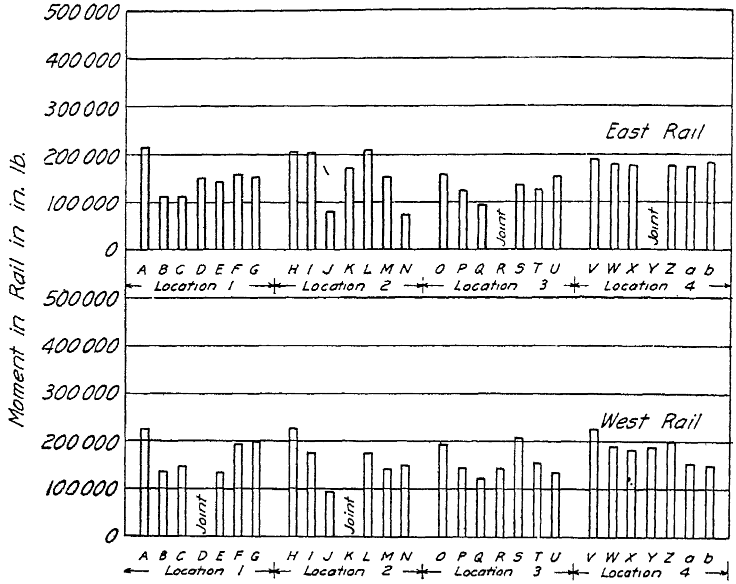

FIG. 13.—Lateral Bending Moment in 110-lb. Rail at Rear Wheel as Car is Moved Along Track—Track B.

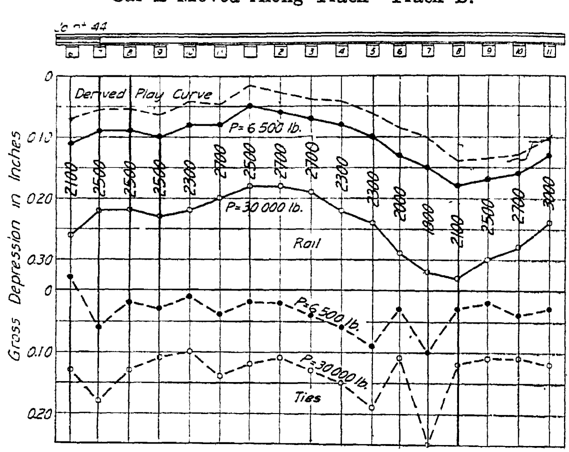

FIG. 14.—Gross Depression of Rail and Tie at Rear Wheel as Wheel Has Been Moved from Tie to Tie and Corresponding Value of u by Approximate Method.

wood shim under the rail. This uniformity of bearing is not peculiar to this type of track construction, for preadzing and preboring and firm fastening of tie-plate to tie have been used for some years in this country. As the tie-plates are held firmly to the tie and the rail is held to the tie-plate, the main source of vertical play is between the tie and its bed in the ballast. This and the natural variation in stiffness of the ballast itself remain as the principal sources for variations in vertical moments from point to point along the track for static loading.

Stiffness of Substructure.—Fig. 14 gives the gross depression of rail and tie on one of the test locations of track B (130-lb. rail). The marked play at the right of the stretch shown was apparent by visual inspection. For the wheel load of 30,000 lb. the gross depression of the rail shown in the upper part of the figure ranges from .18 in. to .33 in. In the lower part of the figure the gross depression of the tie for the heavy load ranges from .1 in. to .25 in., and the diagram indicates that there is a marked variation in the loads taken by the ties. The purpose of showing this figure is to bring out that there is a large variation in the values of the modulus of elasticity of rail support *u*, which here was calculated by an approximate method using the value of the net rail deflection at the rear wheel for each position of load. The values of the modulus so calculated are written below each tie. Even though the stiffness of the 130-lb. rail aids in bridging over poor supports, the modulus ranges from 1800 to 3000 within four tie spaces.

At the left side of Table 2 are given values of the modulus of elasticity of rail support *u* for five locations on the track first referred to (track A, 130-lb. rail). The average value, 2600 lb. per in. per in., represents a very stiff rail support, as track usually runs. At the right are given values for six locations on the second track (track B, 110-lb. rail). For the limestone ballast the moduli indicate a very stiff rail support, averaging 5100, by far the stiffest we have encountered. Part of this extreme stiffness is due to initial compression of the ties by fastening the tie-plates with screw spikes. This also applies to the flint gravel ballast, which has an average value of 2900, a value that is extremely high for gravel. It may be well to remark that for stiff ballast medium variations in the modulus from location to location along the track probably cannot be avoided—it is the variation in stiffness and uniformity from tie to tie and from one group of ties to another nearby that needs remedying—the defects that are responsible for great variations in stresses in rail and in tie and ballast loads.

In closing, I desire to ask you to give careful consideration as time goes on to the desirability of reducing as far as possible the present variability factors in track maintenance—a topic that was discussed in some detail in my talk at the meeting a year ago. The great increase in the stiffness of the track structure in recent years has brought new problems that should not be overlooked. With deep consolidated ballast the average net depression of the rail under load has decreased greatly in high-grade track, perhaps sometimes to a third of what it was a few years ago. At the same time the variation from tie to tie of the play of the rail on its support probably has changed but little—perhaps it has increased from that on less rigid ballast. The variation in bearing of rail on tie-plate and tie has received scant consideration; the proper adzing of the ties will pay good dividends against maintenance costs. In our satisfaction in possessing heavy rail and deep ballast, have we not neglected making progress in important accompanying matters relating to the economics of maintenance? Altogether a little extra cost, perhaps only a better directed effort at uniformity, will relieve track of some of the sources of maintenance troubles.

I would not have you think that the topics mentioned tonight constitute the main part of the forthcoming report of the Committee. Rather I wish that this sketchy talk

will whet your appetite to make a thorough study of its findings after publication is made.

TABLE 1—EFFECT OF SPEED ON JOINT MOMENT RATIO
Representative of change in stresses

Test	Speed in Miles per Hour			
	5	45	70	90
a	.61	.63	.65	.65
b	.41	.50	.56	.68
c	.57	.63	.70	
d	.66	.72	.80	
e	.68	.71		
f	.67	.65	.77	
g	.87	.78	.93	
h	.85	.80	.86	
i	.84	.80	.70	
j	.47	.48	.45	
k	.43	.52	.42	

TABLE 2—MODULUS OF ELASTICITY OF RAIL SUPPORT *u*
The value of *u* is given in pounds per inch per inch of one rail

Location	Track A	Location	Ballast	Track B
1	2500	1	Limestone	3700
2	2900	2	"	5500
3	2200	3	"	6200
4	2600	Average		5100
5	2600	4	Flint	2500
Average	2600	5	"	2600
		6	"	3600
		Average		2900

The President:—Dr. Talbot, I do not have words to thank you for this excellent paper this evening and especially for the outstanding work you have done heretofore. I am going to ask for a rising vote of thanks of the members here.

(The convention arose and applauded Dr. Talbot.)

The President:—When I went to the University of Illinois last December to ask Dr. Talbot to come here he said, "I haven't anything to say. What is the use of my coming there?"

When he said, "No," I said, "That is a nice thing to come clear from New York to Urbana for, to have you say 'No' just before Christmas."

He said, "Oh, all right. I will let you know later."

I have not had a word from him from then until now. He is here.

DISCUSSION ON RAIL

(For Report, see pp. 605-645)

Mr. Earl Stimson (Baltimore & Ohio):—The Rail Committee presents for your consideration several revisions in details of the Rail Specifications, a Specification for Spring Washers, and some changes in the Standard Rail Sections. Mr. Blaess will present the revisions of the Rail Specifications.

Mr. A. F. Blaess (Illinois Central):—The report of Sub-Committee No. 1 of the Rail Committee is found in Bulletin 353, Appendix A, pages 606, 607 and 608 inclusive.

Subject No. 1—Reduction of the Carbon Content and Adjustment of Manganese Content in the Rail Specifications: The upper limits of carbon in the present specifications for 100 to 140-lb. rail were fixed on the basis of experience with lighter weight rail. Records of the heavier rail in service have indicated that they may be too high and several months ago the Manufacturers' Technical Committee suggested that consideration be given to lowering the upper limits of carbon and adjusting the manganese contents. Such consideration has been given by your Committee and recommendation is made for reducing the upper limits of carbon, restricting its range to 13 points, and increasing the manganese. This is shown in Table II on page 607.

The next modification in the chemistry of rail is the change in silicon content. The present specifications stipulate a minimum of 0.15 silicon without restriction as to maximum. A tendency has been noted on some roads towards an increase in the number of failures of rail high in this element. To overcome this it is proposed to specify a range in silicon from a minimum of 0.10 to a maximum of 0.23.

For the purpose of comparison the present chemical requirements as given on page 148 in the Manual are shown in Table I. Proposed chemical requirements recommended by the Committee are shown in Table II. That Table II is shown on page 607.

Classification Markings: Acting upon the report of several members that the requirement in paragraph 17, sub-paragraph (e) of the Rail Specifications, that "all rails of a heat whose carbon content exceeds the mean carbon percentage of the specified range shall have both ends painted blue," has resulted in giving a wider carbon range than desirable for rails for use under conditions contemplated by the specifications.

It is the recommendation of the Committee that sub-paragraph (e) be changed to read:

"All rails of a heat whose carbon content is in the upper five points of the carbon percentage of the specified range shall have both ends painted blue."

Branding and Stamping: In 1931 and 1932 the Association adopted recommendations for branding and stamping rails. It is the thought of the Committee that these recommendations should be incorporated in the Rail Specifications as indicated under "Proposed Paragraph 16".

I don't know that it will be necessary to read those.

The President:—Unless the members wish them read, we will omit them. They were in the report of last year.

Mr. A. F. Blaess:—The purpose of bringing them up now is to get approval of the convention to having them incorporated in the Manual as part of the specifications.

Revision of Form 402-A: While it was stated in last year's report that definite recommendations would be made this year for revision of Form 402-A, Report of Rail Failure in Main Track, such revision is not especially urgent and the Committee believes it may well await the outcome of the joint investigation which will possibly suggest the need for additional information concerning failures in track.

Your Committee recommends:

"1. That carbon and manganese contents for 85 to 140-lb. rail and silicon content for all weights of rail as stipulated in paragraph 2 of Standard Specifications for Open-Hearth Carbon Steel Rails, page 148 of the Manual, be revised as shown in Table II."

I move adoption of Recommendation No. 1.

The President:—Is there any discussion? Are there any remarks?

(The motion was put to a vote and carried.)

Mr. A. F. Blaess:—"2. That sub-paragraph (e) of paragraph 17, of the Standard Specifications for Open-Hearth Steel Rails, page 151 of the Manual, be changed to read as given under 'Classification Markings.'"

I move that recommendation be adopted for publication in the Manual.

The President:—Is there any discussion? Are there any remarks? I believe that these markings have also been approved by the rail manufacturers. Is that correct?

Mr. A. F. Blaess:—Yes. This has been discussed with them and met with their approval.

(The motion was put to vote and carried.)

Mr. A. F. Blaess:—"3. That paragraph 16 of the Standard Specifications for Open-Hearth Carbon Steel Rails as printed on page 151 of the 1929 Manual and repeated herewith, under the heading, 'Present Paragraph 16,' be revised to include the 'Typical Branding,' 'Typical Stamping' and 'Recommended Design of Letters and Numerals to be Used in Stamping,' as adopted by the Association in 1931 and 1932 and appearing on pages 353 and 354 of the 1931 Proceedings, and be revised to read as given herewith under the heading, 'Proposed Paragraph 16.'"

I move adoption of that recommendation for publication in the Manual.

Mr. C. W. Baldridge (Santa Fe):—I should like to ask if the letters and figures for stamping as given here are supposed to be the exact sizes that are to be used on rail.

The President:—He means the dimensions.

Mr. A. F. Blaess:—Yes, sir.

The President:—That is the mathematical size?

Mr. A. F. Blaess:—Yes, sir.

Mr. C. W. Baldridge:—I would suggest that instead of saying they shall be this size to specify that they shall be not less than this size. I see no objection if anybody wants to have them larger. In my experience, the larger figures are a little easier to read than the smaller ones.

Mr. A. F. Blaess:—The Committee considered that and we felt it would be better to have a uniform size letter. For that reason we specified the size mentioned in this report.

The President:—Are you ready to vote? All in favor will say "aye"; contrary, "no." The motion is carried.

Chairman Earl Stimson:—Mr. W. C. Barnes, Engineer of Tests of the Rail Committee, will now present the report on Rail Failure Statistics for 1931, as given in Ap-

pendix C-1, page 610, and on Transverse Fissure Statistics, given as Appendix C-2, on page 624.

Mr. W. C. Barnes (Engineer of Tests, Rail Committee):—I don't think it necessary to take the time to discuss the rail failure statistics in detail as they have been tabulated and compiled in the usual manner. I should just like to point out, however, that their presentation this year embodies an improvement for which we are indebted to Secretary Fritch, namely, the setting up of the tables in type instead of having them made from plates as heretofore. They will be found to be more legible and present a better appearance. Next year we expect to be able to similarly improve the diagrams.

I move that the Rail Failure Statistics as presented in Appendix C-1 be accepted as information.

The President:—Would anyone like to ask any questions in connection with these tables? If not, they will be so received.

Mr. W. C. Barnes:—The Transverse Fissure Statistics are shown in page 624 as Appendix C-2. They include all such failures up to December 31, 1931 which have been reported, and present a cumulative record which now totals 58,277 transverse fissure failures.

This report also is made out in the usual manner and is, I believe, self-explanatory. I would be warranted, possibly, in taking time to call your attention to Fig. 1 at the bottom of page 625, which shows a rather marked decrease in fissure failures which have occurred in actual service since 1929, the first year in which the fissure detector cars were put into any considerable use. No doubt this decrease is influenced quite considerably by the decrease in traffic, but I would say that I have made other studies which have shown me that this decrease is much more marked on roads that have used the detector cars than on those that have not used them. So at least some part of this decrease is due to the effect of detector car work.

I move that this report be accepted as information.

The President:—Is there any question? Any remarks? If not, it will be so received.

Chairman Earl Stimson:—Complying with the insistent demand of the Committee on Outline of Work and the Board of Direction and after a number of years of careful, thorough consideration, your Committee this year presents Specifications for Spring Washers. Mr. Lem Adams will make the presentation.

Mr. Lem Adams (Union Pacific):—About ten years ago the Rail Committee presented a specification for spring washers which was adopted by the Association. At that time there were no specifications in existence and, with only one or two manufacturers of high tension spring washers, we found it necessary in preparing such specifications to adopt a rather low tension. It was found, after a few years, that this did not meet the demands of the railroads, so about two years later another specification was drawn with very high tension. There were, however, a number of defects in this specification, and the manufacturers of relatively low pressure washers were able to supply washers under the specification and yet meet its requirements.

About 1929 this subject was given to the Rail Committee again for the preparation of another specification or the elimination of same. As a consequence, the specification was entirely eliminated from the 1929 Manual. Then this Committee undertook to prepare a new specification, and following is the one that has now been formulated by the Committee.

The Sub-Committee has prepared the following specifications which are recommended for use by those who purchase spring washers. This recommendation of these specifications, however, does not imply any recommendation for or against the use of spring washers, which is a matter outside of the Committee assignment.

I am not going to read the specifications unless you so wish, as the general requirements are shown here on page 635 of Bulletin 353.

I move the adoption of the Specifications for Spring Washers, as submitted in Bulletin 353, pages 635 to 637, inclusive.

The President:—Does anybody want to ask Mr. Adams some questions? Is there any discussion?

(The motion was put to vote and carried.)

Chairman Earl Stimson:—On page 638, Appendix F-2, is given the report on the assignment, "Relative Merits of Rail Sections Heavier than 100 lb. per yard from the Standpoint of Economical Distribution of Metal and Strength."

In studying this subject, it resolved itself into a matter of redesigning the sections, taking into account the economical distribution of metal and the strength of the section. As the result of the study, the Committee unanimously agreed on an improved section to take the place of the 130-lb. R. E. section.

The Sub-Committee handling this matter, whose Chairman, Mr. Michel, is not here, presented a number of designs for an improved 130-lb. section to give more stiffness to the rail and a greater fishing distance and therefore a stronger joint bar. These all varied by small fractions of an inch. When the matter was summed up, it was found that the Pennsylvania 131-lb. section and a section for 130-lb. rail designed by the late Dr. Dudley were so nearly alike the 130-lb. section recommended by the Sub-Committee that in the interests of uniformity and simplified practice and standardization, the various interests that advocated these different designs of section came together, and inasmuch as the Pennsylvania 131-lb. section was already in existence and there was already a considerable tonnage in track, and as this section had given very satisfactory service under heavy traffic for something like two years, the Committee all agreed that that was the section that we would propose in place of the present 130-lb. R. E. section.

You are all familiar with this section. It is given on page 640. Since this report has been out for sometime, you probably have studied the details and are familiar with them. I am not going into that detail but will place the matter before you so that any discussion may be had that may seem necessary. I therefore move the adoption of this 131-lb. section, which will be known as the 131-lb. R.E. section, in place of the 130-lb. R.E. section shown on page 145 of the 1929 Manual, which section is to be withdrawn from the Manual. In other words, the 131-lb. section will take the place of the 130-lb. section.

The President:—Has anyone any discussion on this? I think that possibly some of the members here should be enlightened on some of the high and low points in regard to the determination of coming to this section. I thought that possibly some members on the floor would like to bring out those points. If the Committee does not mind, I would say that you will find the top radius of the various heads is different, though not radically different, from other rail heads that have been in use. The double radius or parabola used throughout the systems in the East produces a quicker cold rolling and forms a contour, and also less overflow on the gage side than is produced on the short radius head.

I thought I would mention that because the Rail Committee is a little modest in explaining some of those details. Would any of the members like to say anything in this connection, particularly the mill men?

Mr. J. C. Irwin (Boston & Albany):—I should like to make one remark and it is not in regard to design. I think that this is a very important step toward national standardization. It is a thing that should be recognized as such and much credit can be given to those who have set aside their personal views in order to arrive at a proper standard for the country.

The President:—Is there any more discussion?

(The motion was put to vote and carried.)

Chairman Earl Stimson:—The second recommendation on page 639 reads: "(2) As the 120, 140 and 150-lb. R. E. rail sections have never been used, and as the tendency is to increase the weight of rail used by increments of 20-lb. instead of 10-lb., it is recommended that these sections shown on pages 144, 146 and 147 of the 1929 Manual be withdrawn." I so move.

The President:—Is there any discussion or remark?

(The motion was put to vote and carried.)

Chairman Earl Stimson:—"(3) In connection with the above recommendations, it is recommended that the table headed 'Application of recommended rail drilling to standard rail sections,' page 162 of the 1929 Manual, be revised to eliminate the drilling for the 120, 130 and 140-lb. R.E. sections." I so move.

(The motion was put to vote and carried.)

Chairman Earl Stimson:—Recommendation No. 4: "It is further recommended that the 'Height of bolt hole above base of rail' of 3¼ in. for the 131-lb. R.E. rail section be added to the table referred to in Recommendation 3." I so move.

(The motion was put to vote and carried.)

Chairman Earl Stimson:—This concludes the Rail Committee's report, Mr. President.

We have the good fortune to have with us tonight Prof. H. F. Moore, of the University of Illinois, who is conducting the transverse fissure rail investigation on the joint account of the Rail Manufacturers' Technical Committee and the Rail Committee, and he will favor us with an address, explaining the work he has been doing at that point.

(Prof. H. F. Moore described the progress being made in the joint investigation of steel rails, conducted at the University of Illinois, and illustrated his remarks with lantern slides.)

The President:—Before dismissing the Committee, I want to refer to the remarks of Mr. Irwin in regard to the adoption of the new 131-lb. R.E. rail section. In the Division IV—Engineering of the A.R.A., a great many Railroad Executives approached me during the past year in regard to why the A.R.E.A. has not been more active in having its Recommended Practices used more generally by the railroads of this country. That question came up at one of the Engineering Division meetings, and we had to get certain typical illustrations to carry out that thought. I reported back to these Executives and told them that the trouble was in their own families.

In order to draw that out, we have to start, for example, in track construction with the rail, because we have to start at the top and work down. That is one of the things I brought out in my address this morning in regard to the Committees correlating those various phases of our work.

I believe that the adoption by this Committee and this Association of the new rail section is one of the greatest steps forward that the Association has made. I believe that it will lead to a greater application by more railroads and to a greater recognition of the outstanding work that this Association has done for so many years. I wish to express my thanks to the Rail Committee for starting it. I wish to thank you for your excellent report and particularly for that on the 131-lb. rail section.

You are excused with the thanks of the Association (Applause).

DISCUSSION ON ROADWAY

(For Report, see pp. 131–165)

Mr. C. W. Baldridge (Santa Fe):—The report of the Roadway Committee will be found in Bulletin 349, page 131. For this year's work the Committee respectfully presents the following report.

Subject No. 1, Revision of the Manual. The Committee have made revisions of the Manual quite thoroughly each year for sometime in the past and this year we were unable to find anything that needed further revision, so far as we could judge it, and have no report to make on that subject.

Subject No. 2, Methods of Roadbed Drainage. The report of the Sub-Committee is found in Appendix B.

This report is a continuation of the report on the same subject as made and adopted last year, and it is the Committee's recommendation that the matter in Appendix B, beginning with the words, "French or Rock Drains," on the first page of the report, and ending with Article 9, be adopted for inclusion in the Manual, following the matter adopted last year.

Mr. Fanning, Chairman of the Sub-Committee, will present the report.

Mr. G. S. Fanning (Erie):—We have been engaged for three years now on the subject of roadbed drainage. The first two years we covered the subjects of surface drainage and sub-surface drainage in detail. This year's report covers the application of these facilities generally to special problems during construction. Almost all of this material is already in the Proceedings or the Manual and this is, in effect, a rearrangement so as to make it fit in with the new drainage material. During the coming year this subject will be continued to deal with special problems of maintenance. It seems unnecessary to read this material, and, although it is offered for the Manual, I will read it by headings only: French or Rock Drains; Special Problems During Construction; Prevention of Soft Spots and Water Pockets; Definitions; Causes; Prevention; Long Cuts; Widening Cuts and Fills; Multiple Tracks; Yards; Passenger Stations; Highway Grade Crossings.

This material is to replace certain material now in the Manual as listed at the bottom of page 136 and the top of page 137.

I move adoption of this report for inclusion in the Manual.

The President:—It has been moved and seconded that the report be adopted for inclusion in the Manual. Is there any discussion on this? Does anyone wish to make any remarks?

(The motion was put to a vote and carried.)

Chairman C. W. Baldridge:—Subject No. 3, as assigned to this Committee, reads: Study of the Service Life of Fence Wire and Specifications for Railway Fence Wire. The Sub-Committee was unable to secure sufficient information during the year to bring in a final report. Therefore the report of the Sub-Committee, as given in Appendix C on page 137, is offered as information. Mr. Pruett is not here and I will therefore pass that subject and go to the next one.

The President:—If there is no objection, we will arrange accordingly. Is there any member who would like to ask any questions or any information from the Committee on this subject? Please proceed.

Chairman C. W. Baldridge:—Perhaps I should have said the subject has been reassigned, and Mr. Pruett will continue the work for the coming year. I anticipate they will have some real information by next year.

Subject No. 4, Investigate the Use of Portable Cribbing in Place of Rigid Retaining Walls and the Utility of the Different Kinds of Cribbing. Mr. A. E. Botts, Chairman of the Sub-Committee, will present the report.

Mr. A. E. Botts (Chesapeake & Ohio):—The report of Sub-Committee No. 4 will be found on pages 139 to 148, inclusive, of Bulletin 349. Data supporting this report was secured from various sources and we think it represents a fair cross-section of the best practices pertaining to the use and utility of portable cribbing. On page 139, under the heading, Materials, paragraph 4, there is an error in the report, wherein it refers to Fig. 10, both open and closed face cribbing. Fig. 10 covers the one face.

The report is self-explanatory and we offer it as information.

The President:—If there is no objection it will be so received. Does any member wish to ask Mr. Botts a question?

Chairman C. W. Baldridge:—The next subject is No. 5, Physical Properties of Soils and their Effect on Roadbed Performances. Mr. Legro, Chairman of the Sub-Committee, is not present and I am asking Mr. Lewis, member of the Commmittee, to present the report.

Mr. E. R. Lewis (Michigan Central):—This assignment, Physical Properties of Soils and their Effect on Roadbed Performance, as found on page 149, is conceived by the Sub-Committee as of such importance and worthy of so much study that this report is intended as only the beginning of what we hope to accomplish. This subject merits research and we anticipate that consideration will extend over a number of years.

The report is offered as information.

The President:—Does anyone wish to ask Mr. Lewis any questions? If not, the report will be so received.

Chairman C. W. Baldridge:—Subject No. 6 assigned to the Committee reads: Drainage Areas and Water Run-Off and the Proper Size of Waterway Openings. This is a subject which the Committee have been working upon for several years and we now believe that we have reached a conclusion. Prof. Jamison Vawter, Chairman of the Sub-Committee, will present the report.

Prof. Jamison Vawter (University of Illinois):—The report of this Sub-Committee is on pages 150 to 152 of Bulletin 349. In this report two additional formulas and references are given in addition to what was in the last report of this Sub-Committee. There is one correction which should be made on page 150, in the second line from the bottom. The phrase "Obtained by observations over a number of years" should be in parentheses. The Committee would like to call attention to certain of the conclusions, namely, a warning against the blind use of formulas, the fact that the same formula cannot be expected to give satisfactory results for both large and small drainage areas, and the value of data such as the Dun tables. The modified Myers formula as given by Jarvis, the Fuller formula, and the "rational method" are also covered in the conclusions. The recommendations presented with the report are as follows:

"The Committee believes that tables similar to the Dun data can best be compiled by the separate railroad companies for their own use, making use of all experience gained in the territory served by them. Attempts made to obtain these data by means of a questionnaire sent to the various roads have not proved successful.

"The Committee recommends the report be accepted as information."

The President:—Are there any questions? If not, it will be so received.

Chairman C. W. Baldridge:—Subject No. 7 reads: Methods of Correcting Soft Spots in Railway Roadbed where it is Impracticable to Stabilize it by Drainage.

Mr. O. H. Wainscott, Chairman of the Sub-Committee, will present the report. It seems Mr. Wainscott is not here this morning. Mr. Brown, will you present the report?

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Mr. W. G. Brown (Florida East Coast):—The report of the Sub-Committee on Methods of Correcting Soft Spots in Railway Roadbed where it is Impracticable to Stabilize it by Drainage is found on page 152 of Bulletin 349, and it is offered as information.

The President:—Does anyone wish to ask Mr. Brown any question? If not, it will be so received.

Chairman C. W. Baldridge:—Subject No. 8 as listed this year reads: Specifications for Overhaul in Grading Contracts and a Recommended Method of Calculating Overhaul. Owing to the impossibility of continuing as Chairman of the Sub-Committee last year, the man then in charge resigned the chairmanship quite late and I undertook to handle the subject myself.

The report on this subject was printed in Bulletin 342 last year and appears on page 315 of that Bulletin. It was carried over for further consideration, but after the year's work was done and our report was ready for presentation to the full Committee last October, the Committee decided to submit the report as it was printed last year with the exception of two words, I believe. Inasmuch as this report is not in your hands except through last year's Bulletin, I presume it would be advisable to read it.

The President:—How long is it?

Chairman C. W. Baldridge:—About three pages of reading matter.

(Chairman Baldridge read Appendix E, page 315 of Bulletin 342 of Vol. 33 of the Proceedings.)

Chairman C. W. Baldridge:—That represents the Specifications for Overhaul and is similar to the specifications previously in the Manual before their removal in 1926. Do you wish to act on these specifications now?

The President:—We will act on this now.

Chairman C. W. Baldridge:—It is moved that the specifications just read be adopted for inclusion in the Manual.

The Chairman read "Method of Computing Overhaul," as shown in Appendix E, page 315 of Bulletin 342, with the following interpolation before the words: "With fine lines," etc.: In this clause I am leaving out the words "for embankment," which were in the printed form last year. It is unnecessary and somewhat confusing and we will therefore omit them.

The President:—Is there any discussion? Are there any remarks?

(The motion was put to a vote and carried.)

The President:—Please proceed, Mr. Baldridge.

Chairman C. W. Baldridge:—The rest of this is just descriptive of how this is handled and is offered as information to be printed in the Proceedings. The specifications already adopted will go in the Manual.

The President:—Will you so move?

Chairman C. W. Baldridge:—I move that the description and material read but not offered for inclusion in the Manual be accepted as information and printed in the Proceedings.

The President:—Mr. Baldridge has said it is already in the Proceedings of last year, in Vol. 33. We will act on this accordingly, because there may be some slight changes there.

(The motion was put to a vote and carried.)

Chairman C. W. Baldridge:—Subject No. 9 assigned to this Committee for this year's work reads: Desirable Width of Roadbed in Cuts and on Fills and Desirable Slopes of Banks Under Varying Conditions of Present-Day Loadings.

Mr. W. M. Ray, Chairman of the Sub-Committee, will present the report.

Mr. W. M. Ray (Baltimore & Ohio):—The report of this Sub-Committee is found on page 158, under Appendix I, Desirable Width of Roadbed in Cuts and on Fills and Desirable Slopes of Banks Under Varying Conditions of Present-Day Loadings. The Sub-Committee studied the material in the Manual on the matter of roadbed widths which are tied into the standard ballast sections in the Manual, with a general provision that the edge of the roadbed should be 18 inches outside the foot of the ballast slope. The ballast sections as shown on pages 103, 104 and 105 of the Manual indicate a different treatment in the section for stone ballast, as compared with the section recommended for gravel ballast. This results in a difficulty in establishing the roadbed width by any uniform method, starting from the ballast section. As a matter of fact, the railroads submitting standard sections plot the ballast section and the roadbed section together and so eliminate this difficulty, but the Sub-Committee felt, under the circumstances, that the differences in the ballast sections and these discrepancies should be reconciled before a further definition can be made as to width of roadbed.

With reference to slopes of banks, the material in the Manual has been examined and it appears that there was a Sub-Committee assignment exactly along similar lines which was treated in Vol. 25 for 1924, page 362, with the following remedies suggested for the adjustment of roadbed under varying conditions of present day loadings:

1. Strengthen the roadbed by better drainage.
2. Strengthen the roadbed by widening same.
3. Help the roadbed to function properly by better distribution of the load—deeper ballast, heavier rail, etc.

This material is submitted as information with the recommendation for further study of the ballast section in this connection. I move that this be accepted as information.

The President:—It has been moved that this report be accepted as information only. Are there any questions?

Vice-President W. P. Wiltsee:—With reference to width of roadbed and especially with reference to sub-ballast which might be considered as a top dressing of the roadbed section, I want to suggest to the Committee that they be very careful and not do anything to take away the importance of ballast and throw it into the roadbed class. Sub-ballast, to my mind, is a ballast, not a part of the roadbed. The roadbed is made generally from local material. Ballast material is material that is foreign and is hauled in to perform various functions. I just call attention to that because I think it is very important in our valuation matters and classifications of accounts.

The President:—Are there any other questions?

Chairman C. W. Baldridge:—The remarks that Mr. Wiltsee just made will be taken into consideration by the Committee on Outline of Work. Incidentally, the subject which has just been reported upon has been discontinued so far as the Roadway Committee is concerned. There was a recommendation made by the Roadway Committee that the Ballast Committee be given that assignment, but I do not know what was done about it.

Subject No. 10 was to Investigate Methods of Protecting Against Drifting Snow and Methods of Removal of Snow on the Line and in Yards and Terminals.

Mr. F. W. Hillman, Chairman of the Sub-Committee, will present the report.

Mr. F. W. Hillman (Chicago & Northwestern):—This report is found on page 159 of Bulletin 349. The subject has two major divisions: Protection and removal. Under protection, consideration is given to removal of obstructions which cause drifting of snow onto tracks and to placing of obstructions which would prevent or retard drifting. Because of irregularity of action of snowstorms no fixed rule can be stated for locating snow fences. However, a general rule is suggested.

The removal of snow is divided into removal on lines and in yards and terminals, and the Committee has outlined a general policy for handling snowstorms. This report is submitted as information.

The President:—Is there any discussion or any remark?

Mr. W. A. Radspinner (Chesapeake & Ohio):—I hope that the members of this Association will not think that I am bringing up this fire prevention matter too often, but on our railroad whenever we have a fire it is my job to prevent a re-occurrence, and the various exceptions that I have brought out are from actual experience. Both this Committee and the Sub-Committee on Snow Melting Devices have recommended the use of casing head gasoline and snow melting oil. We have had two serious fires on the Chesapeake & Ohio from that source. One was in a tower. We require the people who lease and use our property under the Interstate Commerce Commission rules to store casing head gasoline 100 feet off our right-of-way or rather from rails over which a locomotive passes and we store the snow melting oil and casing head gasoline in drums right on our property, sometimes close to an open flame. While it is probably not the province of this Association to enter a campaign of education of the people who use that material, in both instances on our line the damage was due simply to a matter of ignorance. The man went up there with a lantern to get some of the snow melting oil. He burned the tower down and a building that was used for motor cars.

I think if this Association is going to recommend the use of such hazardous liquids as casing head gasoline and snow melting oil on the right-of-way we ought to include in the report some provision for its protection while it is stored on our property.

Mr. F. W. Hillman:—Mr. Radspinner, the Committee on Maintenance of Way Work Equipment has assigned to it the subject, "Types of Snow Melting Devices," which we thought precluded their consideration in our report, although we have suggested where they might be used.

Mr. W. A. Radspinner:—Their report is all right. They call attention to the fire hazard, stating it is a fire hazard. On the question of storing it on our property, whether we should comply with the rules and regulations of the Interstate Commerce Commission in regard to its storage is something that I think we ought to give some consideration.

The President:—I am very glad that you brought that up. The Committee on Outline of Work will take it under consideration for future action. This report is submitted as information and if there is no objection it will be so received. Thank you, Mr. Hillman.

Chairman C. W. Baldridge:—Subject No. 12, as assigned to the Roadway Committee, reads: Specifications for Pipe Line Crossings under Railway Tracks. Mr. P. T. Simons, Chairman of the Sub-Committee, will present the report.

Mr. P. T. Simons (Missouri Pacific):—Specifications for Pipe Line Crossings Under Railway Tracks were submitted to the convention last year as information. These have now been revised for this year's report, as printed in Bulletin 349, page 163. This report covers all essential features of specifications which are now in use on about thirty railways which reported their practices to the Sub-Committee. Suggestions and minor objections were received from the railways but these were reconciled and the report prepared accordingly.

As was stated at the convention last year and as stated again yesterday by members of Committee XX, a number of pipe line companies, through the American Petroleum Institute, objected to the procedure by the A.R.E.A. to adopt specifications which this Committee submitted.

In order to bring about, if possible, the withdrawal of those objections, two conferences were held between committees of the A.R.E.A. and the A.P.I. in June and October,

1932, prior to the date on which the report as printed in Bulletin 349 was adopted by the Roadway Committee. After the second conference, this Committee believed that points in conflict had been adjusted, or as nearly adjusted as could be, to the satisfaction of all concerned. But that was not the situation. In December, 1932, and January this year, the American Petroleum Institute requested that efforts to standardize agreements and specifications for pipe line crossings be discontinued. This request resulted in further efforts to harmonize the views of the two organizations, working through committees, and led to the adoption by your Roadway Committee of further revisions in three paragraphs and in the sketch drawing as printed in the Bulletin, which revisions are as follows:

"6. Casing shall extend at least 45 feet each side from (measured at right angles to) center line of outside track. If additional tracks are constructed in the future, the casing shall be correspondingly extended.

"7. Where warranted by special local conditions, which are mutually agreed to by railway company and the pipe line company, accessible emergency shutoff valves shall be installed within effective distance at each side of crossing.

"9. Crossings under railway tracks of pipe lines carrying extremely volatile or highly inflammable material shall, where practicable, be located where the ground surface slopes downward away from the railway."

The plan shown on page 164 has been revised to agree with the revised paragraph 7 of the specifications, which I just read, by omitting the shutoff valves on each side of the crossing on the drawing, which it is now proposed to substitute for the drawing as printed. There are also some corrections necessary in the note at the bottom of the drawing.

So the specifications as finally revised are now offered for adoption and inclusion in the Manual.

I move the adoption of the revised specifications as just described.

Chairman C. W. Baldridge:—I second the motion.

The President:—Discussion is now in order.

Mr. W. F. Steffens (New York Central):—For quite a number of years since I ceased to be a member of this Association, I have been constantly impressed with the fact that there should be a closer contact between the members of this Association, who represent the purely engineering side, and those who represent the insurance and fire protection details of railroad practice. If ever that feeling was previously justified, it has been emphasized this morning by what I have heard from the Chairman of the Sub-Committee. There are viewpoints of their assignment that ought to be presented and written into your record. I have come here this morning at the solicitation of the Railway Fire Protection Association, inasmuch as a committee has been considering this matter for sometime in that smaller organization. Their work should more and more be related to your work. Many of your men are interested in fire protection and fire prevention, and many of the railway fire prevention men are interested in the other branches of engineering, as you discuss it here.

I was fortunate to be called to represent that organization with this Sub-Committee last October, and at that time thought that a final decision had been reached in all of these details. Since that time I have had practically no contact with the Committee except on a very personal basis, and now find that a very drastic revision has been made in the proposed regulations. I want to put into the record what may happen under certain circumstances. In saying this, bear in mind that some of my very dearest friends are connected with the oil and gas industry. My personal relations with them and those

of the companies that I represented have been, beyond question, on the most cordial basis. Occasionally we have had differences of engineering opinion as is incident to any conference of that nature, but on the whole these have always resulted in a satisfactory compromise, and maximum safety.

When this matter became active several years ago it was stated that pipe lines had existed for many years in the United States, but in nearly all cases conveyed crude oil, quite a different substance than the highly volatile fluid represented by gasoline. This fluid is so well-known today that the phrase "familiarity breeds contempt" applies. In spite of the hazards of gasoline, the activities of fire prevention men of the railroads has reduced to a minimum the list of casualties due to gasoline, to a far greater extent than those due to careless smokers and other forms of carelessness.

The matter of pipe lines, therefore, conveying fluids of this sort, even at low pressure, may well warrant some consideration, but when the pressures are increased as high as 800 pounds per square inch, it begins to be a subject that should be called to the attention of our executives. Ordinarily, a man connected with fire prevention work on any railroad has no authority. He can merely point out special hazards such as are now being discussed, and leave the decision as to disposition to his superior officers. That was exactly my position in the conference with your Sub-Committee, to which I have referred.

To partly visualize the hazard of gasoline under high pressure, apply hydrostatic principles, 233-foot column of water for 100 pounds pressure, multiplied by eight, for a pressure of 200 pounds, and then apply the coefficient of 16 to 12, the ratio of gasoline to water, and note the resulting static head. This would be the condition at a railroad crossing for gasoline under pressure of 800 pounds per square inch. To further visualize the possible results, this height would be almost double the height of the tallest building in New York City.

The President:—Mr. Steffens, if you will pardon me, we should be very glad to hear you, but we should like to know what is the objection to these specifications.

Mr. W. F. Steffens:—Anticipating the possibility of a broken pipe line at or near a railroad crossing, we are justified in knowing how the flow in such event is going to be controlled. I have heard with amazement that control valves are to be eliminated from your proposed specifications. Undoubtedly the question of initial cost of valves is involved. If failure of such a line occurs, what protective steps are to be taken? It has been stated that a break would be noticed at the pumping plant, yet during a recent break in a pipe line flow of natural gas under high pressure continued for an hour after the break was noted. What might happen in case a gasoline line were broken must be recognized. The back flow from a broken line, for example 7,500 gallons per mile from an eight-inch line, may reach railroad property, unless promptly controlled.

Personally, I believe it is a mistake to revise the provision for control valves to such optional form as "where warranted by special conditions." Definite control of pipe line hazards to railroad property by valves convenient to crossings, or through telephone communication to pumping plants, either or both, seem justified, as I stated to the Committee at the meeting in October. These were originally written into the specifications, but have since been eliminated. One of the largest pipe line companies has a supervisory telephone line along its pipe line, and was willing to install an instrument in that line to comply with requirement for protection of railroad property. I believe that adequate protection should be provided before you adopt these specifications, and that the words "where warranted by special conditions," should be eliminated, even if it means another conference with the representatives of the oil industry.

Chairman C. W. Baldridge:—We have had a good many conferences with the A.P.I. I think that most of our Engineers are convinced that the valves in the pipe line are specials. There are some situations where valves are required. I think we are convinced that there are numerous situations where valves are not required. The pipe line people say they are never required. We are very lucky to even have any mention of them in this and have their O.K. in any form at all. The new form here is not particularly different from the other. Originally it stated, "Where local conditions warrant." That has been changed to read: "Where warranted by special local conditions, which are mutually agreed to by the railway company and the pipe line company." There is no difference in the meaning of the two wordings. It makes it just a little easier. The pipe line companies have to have an agreement anyway or they do not cross. That is the answer. If they do not like your agreement they do not cross, unless they are a common carrier, and then we have as much right as they have anyway.

So far as telephones are concerned, that was discussed. That was first put in at the October meeting. The telephone provision was taken out at the meeting in February because very few pipe line companies have telephones which follow the lines. Most of their lines, if they have them, follow the public highways, and they are just about as hard to get to as the public telephones. We felt justified in omitting that in order to get an agreement. I am quite certain that the language as here written is all that we can get and it is a lot more than the A.P.I. wanted us to have. Only this morning I got a letter from them, covering four mimeographed pages, on why they should not have valves in the pipe line, even after they have agreed to it.

I should like to urge the adoption at this time by the Association of these specifications as written. The A.P.I. wanted to put it over for another year. I want to see it go through, with the modifications they have agreed to.

The President:—Does anyone else care to discuss this?

Mr. W. F. Steffens:—Will you ask your Committee to please state to the Association what occurred at Catlettsburg, when a pipe line failed near a railroad, and what occurred recently when one of Mr. Simons' main lines was out of business for twenty-four hours due to an oil line failure.

Mr. P. T. Simons:—One failure of a pipe line carrying natural gas caused a delay of about twenty-four hours on the main line of the Missouri Pacific. That led to the adoption by the Missouri Pacific of the specification requiring the shutoff valves. That was one of the principal reasons for adopting that feature of the specification.

It seemed to the Committee, as stated by Mr. Baldridge, that these valves should be left in, and they are being left in by this paragraph 7.

Another point that Mr. Steffens touched on was the matter of pressure. That was discussed quite extensively in the Sub-Committee, but it got to be such a complicated matter that this Committee just could not handle it with any satisfaction at all, so we put in the first paragraph, the opening paragraph, the reference to the pressure, which is:

> "Pipe lines included under these specifications are those installed to carry oil, gas, gasoline or other inflammable or highly volatile substance, under pressure, or any substance which from its nature or pressure might cause damage if escaping on or in vicinity of railway property."

We omitted any details with regard to the pressure feature.

The President:—Does anybody else wish to discuss this subject?

Mr. W. A. Radspinner (Chesapeake & Ohio):—We furnished the Committee with reports of explosions that we had had from the gasoline lines, one that had exploded under our track and one adjacent to our track. I think that, as Mr. Baldridge has said, the locating of the crossings on the railroad will have a good bit to do with that. The

objection that I had was to the vent pipe being a minimum of four feet. If you run that vent pipe four feet out of the ground, or even eight feet, along some of those branch lines in West Virginia, the natives will be sure to try to find out what is in it. If you cross the track at a place where it is not necessary to have that pipe vent, where the casing pipe is open at both ends, that objection can be eliminated. I think the railroad companies by selecting their crossing sites can control that difficulty. From my own standpoint of fire prevention I think the report is very good.

The President:—Is there anybody else? Are you ready for the question?

(The motion was put to a vote and carried.)

The President:—Maybe that report took a great deal of time, but one of the remarks I made yesterday was in regard to the attacks made in Washington and elsewhere on the work we have done. This has been very valuable.

Chairman C. W. Baldridge:—This completes the report of the Roadway Committee.

The President:—Are there any questions you want to ask this Committee? If not, they are excused with the thanks of the Association (Applause).

DISCUSSION ON BALLAST

(For Report, see pp. 521–531)

Mr. A. P. Crosley (Reading):—The report of Committee II—Ballast is found on page 521, Bulletin 352.

The first subject is Revision of Manual. That subject will be submitted by the Sub-Committee handling Assignment No. 6, found in Appendix E. It will be taken up as we get to that assignment.

The second assignment, Specifications for Prepared Gravel Ballast, will be found on page 522, and is a progress report. Unless there are some questions you want to ask on that we will pass over it.

The third assignment is Specifications for Stone Ballast, and that is found on page 526. The report will be submitted by Mr. Podmore, Chairman of the Sub-Committee.

Mr. J. M. Podmore (New York Central):—Appendix B, Specifications for Stone Ballast, Including Best Method of Testing Resistance to Weathering, is found on page 526.

It is recommended that the report be received as information.

The President:—As I understand it, the Modified Abrasion Test is also offered as information?

Mr. J. M. Podmore:—Yes, sir.

The President:—Are there any questions or remarks? If not, it will be so received.

Chairman A. P. Crosley:—The fourth subject, Comparative Costs of Maintaining Track on Various Kinds of Ballast, will be found in Appendix C, page 527, and the report will be submitted by Mr. Hubbard, Chairman of the Sub-Committee.

Mr. Daniel Hubbard (Chesapeake & Ohio):—Your Committee for the last several years has submitted certain figures showing comparative costs on gravel and stone ballast sections. This year we have only been able to obtain comparative sections on one mile of track, and it is recommended that this information be accepted as a progress report.

The President:—If there is no objection, it will be so received.

Chairman A. P. Crosley:—The fifth subject, Effects of Different Kinds of Ballast on Life of Ties, etc., will be found on page 528 under Appendix D. The report will be submitted by Mr. Dunn, Chairman of the Sub-Committee.

Mr. M. I. Dunn (Chesapeake & Ohio):—This is a new subject assigned this year. We have not put out any questionnaires to the Association as a whole, but we have had the benefit of a good many opinions and letters from representative members of the Association. The information that we have prepared is submitted as information only at this time and we desire that it be so accepted.

The President:—Is there any member who would like to ask Mr. Dunn any questions? If not, the report will be received as information.

Chairman A. P. Crosley:—The sixth subject, Determine Proper Depth and Kind of Sub-Ballast, will be found in Appendix E, page 530. This will be submitted by Mr. Kennedy, Chairman of the Sub-Committee.

Mr. A. D. Kennedy (Santa Fe):—In the first place, there is a typographical omission in the second paragraph. In the fifth line, between the words "of" and "certain," the following words should be inserted: "the various materials used for sub-ballast except that within." I am going to read the paragraph as it should be, with the correction: "From the replies received, the Committee concludes that many materials such as stone screenings, pit-run gravel, cinders, slag, sand, etc., are used for sub-ballast with satisfactory results, and that, undoubtedly, the availability of supply generally determines both the depth and kind of material to use. Therefore, no recommendation is being made

regarding the relative merits of the various materials used for sub-ballast except that within certain limits, materials of smaller aggregates are to be preferred, for such materials have a greater tendency to prevent roadbed materials working up into the top-ballast, which is one of the principal functions of a sub-ballast."

The conclusions of the Committee are based on replies received to a questionnaire, the details of which were given in last year's Bulletin. These replies were rather indefinite and general in character. The Committee can only make a general conclusion, which is that conditions determine the depth of sub-ballast and that the availability determines the kind. Of course, the ratio between the top-ballast and the sub-ballast is to be determined by governing local conditions.

In considering this subject, the Committee thinks it advisable to recommend certain revisions in the 1929 Manual. The first of these is the definition of sub-ballast. The Committee is of the opinion that it should be brought out more clearly that the sub-ballast is really a part of the ballast section, and with that in view I move that the present definition of "Sub-Ballast", now appearing on page 93 of the 1929 Manual, which reads: "Any material of a superior character which is spread on the finished sub-grade of the roadbed and below the top-ballast to provide better drainage, prevent up-heaval by frost and better distribute the load over the roadbed," be changed to read: "That portion of the ballast next to the subgrade—a strata of material superior in character to that in the subgrade and placed next to it to give a better foundation for the top-ballast; provide better drainage and a more uniform distribution of the load over the roadbed, acting as a cushion between the top-ballast and the roadbed, thereby retarding the action of the roadbed material from working up into the top-ballast."

Mr. Robert H. Ford (Rock Island):—I have read this report with a great deal of interest and the suggestions I have to make may perhaps be more properly addressed to the Board than to the Committee.

I have been able to follow the Committee on the text but not on the result of their conclusions. The proper depth of ballast has been stated as 24 inches. Proper depth of ballast depends upon physical conditions and operating requirements and cannot be thus stated arbitrarily.

While a definite depth of ballast cannot be stated except in general terms, nevertheless the Committee can greatly aid the Association if they would report the fundamentals by which the proper depth of ballast may be determined. They can also show what would be the proper depth of ballast under certain empirical conditions, taken from actual examples of various classes of track under known conditions.

The President:—In view of Mr. Ford's remarks, Mr. Crosley, do you still want to carry this through as Recommended Practice for the Manual, as the Sub-Committee has recommended?

Chairman A. P. Crosley:—Mr. President, I understand that Mr. Ford is dealing more with the recommendations which we have included further on in the report but which have not been presented formally before the convention. What we have included in the motion at the present time is the change of definition of Sub-ballast, which does not carry with it any recommendation for depth at all. The question of depth is included in a second recommendation and which we have not presented at the present time. What we have asked for is approval of the recommendation for the change in the definition of Sub-ballast only. That is the only motion that is before the house at the present time.

In the present definition of sub-ballast as appearing in the 1929 Manual, there is no depth given. The same applies in the suggested definition, namely that we are not suggesting that the depth be included in the definition.

Mr. Robert H. Ford:—If this is a fact, it would, I am sure, justify the Committee in withdrawing the subject for further study.

There is a great deal of additional data available on the subject which may not have come to the attention of the Committee. This includes, among others, your own paper, Mr. Chairman, presented last year before the Maintenance of Way Association of Chicago.

The President:—Is there anyone else who wishes to offer discussion on this?

Mr. E. R. Lewis (Michigan Central):—On this point I desire to support Mr. Ford's contention. There are other things in this report that make me wish we might defer including it in the Manual. I think the definition of sub-ballast in several ways could be modified to ultimate advantage.

The President:—Anybody else? Mr. Crosley, the Chairman, feels that we should ascertain what the Association wants. Are you ready for the question? All in favor will say "aye"; contrary, "no.". I don't know how the Democrats and Republicans are voting. Now, all those in favor will say "aye"; contrary, "no."

Mr. Robert H. Ford:—I doubt if the motion is understood.

The President:—Will you repeat the motion?

Chairman A. P. Crosley:—The motion made and seconded before was that the definition of Sub-Ballast, as appearing on page 531 of Bulletin 352, be changed to read as shown on that page.

Mr. Robert H. Ford:—I move to amend, by adding that this subject be referred back to the Committee for further study and report next year.

Mr. E. R. Lewis:—I second the motion.

The President:—We will vote on the amendment of Mr. Ford, that this be referred back to the Committee for consideration and report next year. Do you all understand that amendment? All in favor will say "aye"; contrary, "no." All those in favor will hold up their hands. Now those opposed. The "noes" have it. The amendment is lost.

Now we will vote on the original motion for adoption and inclusion in the Manual. All in favor will say "aye"; contrary, "no." The "ayes" have it and the motion is carried.

Mr. A. D. Kennedy:—In view of the discussion regarding this motion, the Committee desires to not submit the other changes and it will take them back for further consideration next year.

I want to make one more remark. On the questionnaire that was submitted to the railroads regarding how to determine the proper depth and kind of sub-ballast, I wish to emphasize that the replies to the questionnaire were very indefinite and the Committee was unable to come to any definite conclusion. If the Committee is to make a further report in a more definite manner, then it certainly must have the cooperation of members of the Association.

Mr. Robert H. Ford:—I shall be glad to be of service to the Committee and am hopeful that this discussion will result in constructive suggestions from the Association. Members with practical experience or with scientific knowledge on this subject, owe it to the Committee to aid in every way possible, because after all, these subjects have a direct relation to greater economy and efficiency in maintenance, with corresponding decreases in the cost of railway operation, and these are matters in which we are all especially interested at this time.

Past-President Edwin F. Wendt:—I endorse what Mr. Wiltsee said this morning in connection with the report of the Committee on Roadway. His remark is equally applicable to the work of this Committee. The point I wish to make is this: I hope that the Committee will hold that ballast is ballast, whether it is sub-ballast or called by some

other name. The danger is that the public may get the idea that sub-ballast is not ballast. Personally, I hold that sub-ballast is ballast.

The President:—In this connection, I hope that this Committee does not have any ill feeling toward me, but I threw Committees I and II together in my suggestion so that they could coordinate and cooperate. I don't believe half of us realize and appreciate what the proper cross-section of our railroads mean, with its sub-ballast and its proper ballast, whatever names you care to use. I am glad that Mr. Ford brought that out. We had an interesting report a year or so ago. I happened to be out in the hall and saw the sign "Ballast" up there. I said, "That is all right; I will speak on Ballast." I am going to tell you that I am "hipped" on ballast—the preferred ballast. What I mean by preferred ballast is the proper ballast for the service conditions. That has been brought out very clearly in the past two years by Dr. Talbot in his reports and on the slides, where he showed that the proper ballast and the proper depth of ballast is as essential as the rail itself.

I want to thank this Committee for their good work, and they are now excused with the thanks of the Association (Applause).

DISCUSSION ON TRACK

(For Report, see pp. 491–520)

Mr. C. J. Geyer (Chesapeake & Ohio):—The report of Committee V—Track, is presented in Bulletin 352, pages 491 to 520, inclusive. Some of the recommendations for Revision of the Manual are contingent on approval of other plans to be presented in Sub-Committee reports. If there is no objection, I will first present the Sub-Committee reports and handle Appendix A last.

The President:—There is no objection at all.

Vice-Chairman C. J. Geyer:—The Committee reports progress on Subject 1-A, Appendix B, Specifications for Soft Steel Track Spikes; Subject 6, Corrosion of Rail and Fastenings in Tunnels; Subject 8, Effect of Existing Materials in Track on the Design of Tie Plates and Punching Thereof; Subject 11, Appendix L, Desirable Tightness of Track Joints; Subject 12, Appendix M, Reclamation of Serviceable Materials from Scrap and Retired Maintenance of Way and Structure Machines, Tools and Appliances.

Subject 2, Appendix C, will be presented by Mr. C. W. Breed, Chairman of the Sub-Committee. I believe Mr. Breed is absent, so I will ask Mr. Hogan, a member of the Committee, to present this report.

Mr. J. E. Hogan (Chesapeake & Ohio):—Your Committee's report on this subject is contained in Bulletin 352, pages 493 to 508. This report is submitted just as information and we recommend that the subject be continued further.

The President:—This Sub-Committee has sent out several questionnaires in regard to checking up on this matter on lining of curves and they would appreciate it very much if you would reply to their questionnaire and give them such information so that they can come to some conclusions. Thank you, Mr. Hogan.

Vice-Chairman C. J. Geyer:—Subject 3, Appendix D, will be presented by Mr. G. M. Strachan, Chairman of the Sub-Committee.

Mr. G. M. Strachan (Santa Fe):—Appendix D, page 508, covers Plans and Specifications for Track Tools.

(Mr. Strachan read the report as shown on page 508, Bulletin 352, including the Conclusions.)

Mr. G. M. Strachan:—I move its adoption.

The President:—I assume that the tool manufacturers have been considered in this?

Mr. G. M. Strachan:—Yes, they have been consulted.

(The motion was put to a vote and carried.)

Vice-Chairman C. J. Geyer:—Subject 4, Appendix E, will be presented by Mr. O F. Harting, Chairman of the Sub-Committee.

Mr. O. F. Harting (Terminal Railroad Association of St. Louis):—The report of this Sub-Committee is found on page 510. The assignment is Plans for Switches, Frogs, Crossings, Slip Switches, Etc.

The plan presented in this Appendix, and the Revision of the Manual in Appendix A coming under this subject, were prepared by this Sub-Committee in conference with the Standardization Committee of the Manganese Track Society.

The Committee presents at this time, for adoption as recommended practice, Plan No. 600-A, showing the application of wing wheel risers to manganese steel frogs, railbound, solid and self-guarded. This feature for manganese steel frogs is now in general use and the plan was prepared to assure uniform practice, when wing wheel risers are wanted.

These wing wheel risers elevate the wheels and prevent damage from unduly striking the point of the frog.

The Committee recommends that Plan No. 600-A, dated September, 1932, entitled A.R.E.A. Application of Wing Wheel Risers to Manganese Steel Frogs Railbound, Solid and Solid Self-Guarded, be adopted as recommended practice and printed in the Manual. I so move, Mr. President.

(The motion was put to vote and carried.)

Mr. O. F. Harting:—Some of the railways have experienced broken switch points made of rolled manganese steel rails, due to the progression of incipient cracks at the bolt holes. Tests made by the Lorain Steel Company and the Bethlehem Steel Company indicate that the holes should be drilled and not punched and that the burrs should be removed by grinding.

The Committee therefore offers as information the following recommendation:

"That the bolt holes in switch points made of rolled manganese steel rails be drilled and not punched and that the burrs be removed by grinding."

The President:—If there is no objection, it will be so received.

Vice-Chairman C. J. Geyer:—Subject 5, Appendix F, will be presented by Mr. E. W. Caruthers.

Mr. E. W. Caruthers (Pennsylvania):—In connection with the assignment of Track Construction in Paved Streets, Plans 987, "Straight Double Tongue Switches for Engine Wheel Base not over 14 ft. 6 in. for Use in Paved Streets," and 988, "Straight Double Tongue Switches for Engine Wheel Base over 14 ft. 6 in., but not exceeding 19 ft. 0 in. for Use in Paved Streets," were offered at the convention in 1932 for information. No adverse comments have been received and your Committee now wishes to offer the plans for adoption as Recommended Practice.

These plans have been prepared in conference with the Manganese Track Society, and embody the general details of design, and are interchangeable with switches of this type now in use by some railroads.

Conclusions: The Committee recommends that Plans 987, "Straight Double Tongue Switches for Engine Wheel Base not over 14 ft. 6 in. for Use in Paved Streets," dated November, 1931, and 988, "Straight Double Tongue Switches for Engine Wheel Base over 14 ft. 6 in., but not exceeding 19 ft. 0 in. for Use in Paved Streets," dated November, 1931, be adopted as Recommended Practice and printed in the Manual.

I so move.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Vice-Chairman C. J. Geyer:—Subject 7, Appendix H, is Gage of Track and Elevation of Curves with Reference to the Use of Roller Bearings on Railway Equipment, collaborating with the Mechanical Division, A.R.A. Mr. C. W. Breed is Chairman of that Sub-Committee; he is absent. This is offered as information and is reported on page 511. The conclusions are:

"There is no different problem in the selection of the proper elevation for curves over which it is desired to operate railway equipment using roller bearings than is present if equipment is supplied with ordinary bearings."

This is an information report and the subject will be continued.

The President:—If there is no objection, the report will be so received.

Vice-Chairman C. J. Geyer:—Subject 9, Appendix J, starting on page 512, reads: Practicability of Using Reflex Units for Switch Lamps and Targets. I believe Mr. Myers, Chairman of the Sub-Committee, is absent. This report is presented as information and the subject will be continued.

The President:—If there is no discussion or objection the report will be received as information.

Vice-Chairman C. J. Geyer:—Subject 10, Appendix K, will be presented by the Chairman of the Sub-Committee, Col. W. G. Arn.

Col. W. G. Arn (Illinois Central):—The subject is "Selective Welding Up at Joints, Instead of Welding Out of Face." The detailed information obtained from the questionnaire is given on pages 515 to 518, inclusive, Bulletin 352.

To summarize this information, I will state that two processes are in somewhat general use, the oxy-acetylene process and the electric process. The oxy-acetylene process has been in use either for long periods of time or on an extensive scale on about twenty-nine systems. The method of determining when rail ends should be built up varies widely, from a minimum of .03 in. up to a maximum of 3/32 in.

One of the questions in the questionnaire was: "If you use both 'out-of-face' and 'selective' building up of rail ends, what determines which method to be used in each location?" Many of the replies to this question were the same as to Question No. 3, the question apparently not being understood. Of those who replied, one builds up out-of-face when 40 per cent have reached the allowable limit of wear, two when more than 50 per cent of the rail ends have reached the allowable limit of wear. One uses the out-of-face method on the low side of the curve only, one (uses the out-of-face method) when practically all rail ends are worn to the established limit of wear.

The selective method is employed by one company principally in yards and on the low side of curves, by one company in yards and terminals only, by another only on curves and in special cases, such as washout or slide territory. Two companies use the selective method only to a limited extent for the worst joints until the territory is ready for the out-of-face method, one company only on comparatively new rail when there is considerable chipping, and also to harden ends of soft rail. Two other companies use it only in special cases.

(Col. Arn presented Appendix K in detail, starting with the third paragraph on page 516 of Bulletin 352 and continuing through the Conclusions on page 518.)

Col. W. G. Arn:—This is a progress report and is offered as information.

The President:—If there is no objection, the report will be so received. In regard to heating rail ends, I think you will find the Rail Committee dealing with that subject. The Track Committee will collaborate with them.

Vice-Chairman C. J. Geyer:—Subject 13, Appendix N, covering Standard Wheel Flanges, Treads and Gages, appears beginning on page 519. This subject has been under discussion for several years, and at the last convention Plan No. 790, dated September 1931, was presented with the view of offering it for adoption, but the discussion in the Committee just prior to the presentation of the report developed the advisability of some changes and it was offered as information only. This plan has now been revised and amplified for clarity, and to more comprehensively cover the subject.

The data collected and field measurements taken on this subject and references to conferences held are outlined in the Committee's report for last year, published in the 1932 Proceedings, Vol. 33, page 586, and discussions on the subject will be found on pages 818 and 819 in the 1932 Proceedings. The data already presented will not be repeated here, but the following summary is now submitted.

"With 4 ft. 8½ in. gage and 1¾ in. flangeways the clearance for cast chilled wheels and for large-flange locomotive wheels is approximately ⅜ in. on the gage side and practically nothing on the guard side, especially when wheels are tread worn. The plan now presented recommends, for new work, flangeways, 1⅞ in. wide, with tolerances nothing over and 1/16 in. under, and maximum guard face gage in crossings 4 ft. 4⅞ in. For maintenance the frog and crossing limit gage as outlined is recommended.

"This subject is now considered more important than heretofore, because heavier rails and more rigid track structures are now used, particularly in new work. In lighter rail work and in worn track there is a degree of flexibility, which cannot be counted upon in new heavy-rail trackwork of rigid construction. Furthermore, the elimination of track distortion will add to the life of trackwork fixtures; consequently there should be a considerable saving in maintenance costs with track maintained within the limits specified on the plan now presented.

"Revision of existing frog and crossing plans, to conform to Plan No. 790, are outlined in 1933 Index Supplement, pages 4, 5 and 6, presented in Appendix A. If these revisions are approved, it is the intention to incorporate them on the plans affected, thereby avoiding confusion by making it unnecessary to refer to the Index Supplement for the revisions specified.

"Conclusions: The Committee recommends that Plan No. 790, dated Revised November 1932, A.R.E.A. Data for Gages and Flangeways at Frogs and Crossings, showing Limits where Gage is not Widened for Curvature, submitted herewith, be adopted as Recommended Practice and printed in the Manual."

I so move.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

The President:—This is the first time you have had any track plans or any formulas in regard to tolerances on track construction. This is a subject that has been the subject of discussion between the Mechanical Division of the A.R.A. and the Track Committee.

Vice-Chairman C. J. Geyer:—I might say that in the development of this plan and the recommendation you have just adopted the Committee is deeply indebted for the helpful cooperation of the Mechanical Division of the A.R.A. and the Association of Manufacturers of Chilled Car Wheels, and particularly to Mr. F. K. Vial, Vice-President of the Griffin Wheel Company.

The recommendations for Revision of the Manual appear under Appendix A, beginning on page 492.

The Committee recommends the revision of the Index and Index Supplement to the A.R.E.A. Trackwork Plans and Specifications, pages 1, 2, 3 and 4, dated 1932, by the substitution of a revised Index and Index Supplement dated 1933, pages 1, 2, 3, 4, 5 and 6, listing existant plans and specifications and including the new plans presented herewith.

The revised sheets immediately follow page 520.

Pages 4, 5 and 6 (the Index Supplement) describe revisions to the plans which are identified on Index pages 1, 2 and 3 by the letter "x" following the serial number.

The revisions of the Index Supplement consist of the following additions:

Notes for plans of frogs, crossings and guard rails to make said plans consistent with Plan No. 790, which is now being offered for Recommended Practice in Appendix N and shows a standard width of flangeway of 1⅞ in.; Plan No. 790 also makes necessary revision of paragraph 33 of Appendix B and of the definition "Flangeway Width," in Appendix C of the A.R.E.A. Specifications for Switches, Frogs, Crossings and Guard Rails.

Notes for plans of manganese steel frogs, solid and self-guarded, for laying out flangeways wider than 1¾ in.

Notes for other plans to make them consistent with recently adopted plans and to make minor corrections.

Attention is also called to revision in length of tongue switches for paved streets, as specified in revised Index Supplement in reference to Plans 980 and 982.

The Committee also recommends that Plan No. 11—Claw Bar, adopted by the Association in 1930, be withdrawn from the Manual and that Plan No. 11, dated September 1932, be substituted therefor. The new plan does not change the Claw Bar now appearing in the Manual, but does show an alternate in addition to the approved design."

I move the adoption of Appendix A.

The President:—It has been moved and seconded that we adopt these revisions in Appendix A, which practically brings the Appendix and Index up to date. Are there any questions?

(The motion was put to vote and carried.)

Vice-Chairman C. J. Geyer:—Appendix O, Subject 14, will be presented by Colonel Arn, Chairman of the Sub-Committee.

Col. W. G. Arn (Illinois Central):—You will find this report in full on page 502 of Bulletin 352. The Mechanical Sub-Committee referred to made an additional check showing considerable improvement in the maintenance of brine retaining devices on cars that were so equipped, as follows: In 1928 they inspected 493 cars and found 61.3 per cent defective; in 1932 they made a check of 536 cars and found only 30.4 per cent defective.

The Mechanical Division Sub-Committee reported that there are about 160,000 of the open-bunker type of cars used mainly for fruit and vegetables on which there is no device for retaining the water from melted ice. Of the open-bunker type of cars, however, only about 2 per cent at any one time are actually dripping brine. In these cars the amount of salt varies from 3 per cent to 15 per cent of the amount of ice. They estimate that it will cost about $300 per car to equip them with retaining devices, or, for that number of cars, a total of $48,000,000. However, we estimate the damage due to brine drippings annually at about $2,100,000, which would, capitalized at 5 per cent, equal $42,000,000, indicating that the expense of equipping these cars would not be justified, particularly as these cars are responsible for only a part of the brine dripping, and probably a minor part. Defective apparatus on brine retaining cars probably accounts for the bulk of the drippings. If their expense is estimated 100 per cent too high, or if our estimate of the damage is too low, accounting for 50 per cent either way, the saving would be only 9 per cent, and no railroad is investing to save 9 per cent these days. That is a progress report.

Vice-Chairman C. J. Geyer:—That concludes our report.

The President:—Are there any questions to be asked? I have been with this Committee for a good many years and I don't know whether it would be proper for me to say what I should like to say. However, since I am going out as President of this Association this afternoon, I should like to say to you how I feel about this. This Committee has been outstanding in the past. It has done good work and it is doing good work now, and it always will. It is excused with the thanks of the Association (Applause).

DISCUSSION ON TIES

(For Report, see pp. 323–353)

Mr. W. J. Burton (Missouri Pacific):—This report is contained in Bulletin 351. In order to save time, I am not going to call on Chairmen of Sub-Committees who merely report progress but I will call on those who have material to report.

The first subject is reported on page 324, Adherence to Standard Specifications for Cross-Ties, and Mr. Foley, Chairman of the Sub-Committee, will present this report.

Mr. John Foley (Pennsylvania):—On page 324 you will find the report on Adherence to Standard Specifications for Cross-Ties. Not many ties were purchased during 1932. The few that were taken up represent quality that we consider in accordance with the standard. The Committee would like to call attention to the danger that exists in accepting, when purchases are renewed, ties which have been manufactured so long that they have deteriorated. The Committee is glad to report that another railroad joined the many that are using the standard specifications. There are now only a very few railroads non-standard.

The President:—That report is presented as information?

Mr. John Foley (Pennsylvania):—Yes, sir.

The President:—If there is no objection, it will be received as information.

Chairman W. J. Burton:—The next subject is reported on page 324. For more than twenty years the Committee have been annually reporting the results with so-called substitute ties. The report this year is merely a continuation of a subject which twenty years ago was more or less alive but which is today not quite so alive.

Attention is called to the summary of the tests which have been made up to date, beginning with 1878, which is found on page 329. This represents considerable work on the part of the Sub-Committee.

This report on the subject, Substitute Ties, is merely given in response to the instruction to the Committee to report on the subject and is offered for information.

The next subject assigned is reported on page 332. Owing to the makeup of the Bulletin, there may be some little confusion, as on the same page there is the beginning of the next subject before Subject No. 4 is completed.

This Subject No. 4 covers the report of statistics of tie renewals on all Class I roads in the United States and the major ones in Canada. This is the fifth year in which the Committee has reported on this subject in the present form, and, as announced when the statistics were first originated, the Committee have now compiled five-year averages. These five-year averages will be found in Table C, beginning on page 343.

The Committee wish particularly to call attention to figures given in Tables A and B relating to the traffic of the roads. In Table B, Column 9, will be found a density of traffic figures for each railroad, which represents the equated gross ton miles per mile of maintained track. This figure, it is believed by the Committee, will be found quite useful in studies of subjects other than Ties.

President Neubert has called my attention to the change in method of getting out this information, which will be effective this year. The figures in this table as now presented represent the year 1931. There has been a considerable lag between the time the statistics are prepared and the time they are published. It is now proposed to publish these in the first Bulletin each year so that they will be available much earlier in the year.

One point that will be found of interest by those who study these renewal statistics, and which almost warrant a general statement, is that the better the tie, as measured by the higher price or the higher cost, the lower will be the total tie cost per maintained mile. This general statement is not quite true but it is so nearly true that it should be food for serious thought by those who have tie policies and tie practices under their jurisdictions. The roads which pay the most per tie, speaking generally, have the lowest costs per maintained mile.

The next subject is also started on page 332, Method of Proper Comparison of Renewal Costs per Mile Maintained, with Adjustment for Variables such as Traffic Density, Rate of Installation of Treated Ties, etc.

This report will be presented by the Chairman of the Sub-Committee, Mr. S. E. Shoup.

Mr. S. E. Shoup (Kansas City Southern):—Statistics, as such, which are not thoroughly understood or digested may oftentimes be misleading rather than helpful. The object of the Sub-Committee was to explain the variables which had to be taken into account in the study of the tables Mr. Burton has just referred to, submitted by the Sub-Committee on Subject No. 4. That Sub-Committee has presented information on traffic density, number of ties in the track, rate of installation of treated ties, and so forth, which will be found valuable in making satisfactory comparisons, providing the variables called attention to in this report are given proper weight.

It was the hope of the Committee when we started on this subject to present a more or less mathematical determination. That was found hopeless. A series of tests by trial and error clearly precluded the presentation of any such formula in mathematical form. Thank you.

This is presented as information.

The President:—If there is no objection, it will be so received.

In connection with the remark that Mr. Burton made a few minutes ago in regard to the highest priced tie, I believe that he meant also in using that expression that a higher quality or a better quality of tie produces the least cost. In that same connection, I had to analyze certain figures on a certain property. I found that we were using a cheap tie, but the proportion of cost in the tie account was higher than that of another railroad that was using a higher priced and a better quality of tie. I believe that is what he meant.

Chairman W. J. Burton:—Yes, sir. I intended to mean that quality and price, generally speaking, go together.

The next subject is found on page 348. This is merely a progress report of a Committee which has already done a large amount of work but which is not yet ready for presentation.

The next subject, Most Economical Method of Distributing Ties from Treating Plants to Points where they are to be Used, will be reported on by Mr. Duncan, Chairman of the Sub-Committee.

Mr. H. R. Duncan (Chicago, Burlington & Quincy):—When your Committee first considered this subject they had in mind that they would be able to make a recommendation that could be followed by all railroads. After going into it in considerable

detail, we determined that what might be the answer for one railroad would not be satisfactory for others. There are several factors that must be taken into consideration before a method can be decided upon for any individual railroad. There is the question of the location of the treating plant, the movement of the equipment, light or backhaul of equipment for the loading, the distance from the treating plant.

As the conditions vary so greatly as between different locations, your Committee has found it impossible to recommend any one practice as being superior and, therefore, has endeavored to list some factors that must be given consideration in determining the method to be followed in distributing ties from treating plants to points where they are to be used. It is the conclusion that a careful study should be made by all departments concerned to determine the best method of distributing ties from any individual treating plant.

Those factors have been listed in the report. I will not take the time to read the entire report. This report is presented as information.

The President:—If there is no objection, it will be so received.

Chairman W. J. Burton:—The next subject is one on which the Committee also reports progress. I will not take time to go into it more than to say about every ten years the Committee has reported on the best renewal practices with the idea of keeping up with changing conditions from time to time. This report is now in process of preparation and will be ready sometime during the year.

The next subject, Economics of the Use of 8-Foot 6-Inch and 9-Foot Ties as Compared with 8-Foot Ties, is also one that is at present under investigation. During the coming year the Committee expects to originate certain service tests in such a way as to obtain a result as quickly as possible and the report now is awaiting the results of those tests. During the last year conditions have not been favorable for such tests.

The last subject, No. 10, found on page 352, Economical Uses for Old Ties which must be Removed from Track and Bridges—A, Treated; B, Untreated, prior to their having served their full life as cross-ties, will be reported on by the Chairman, Mr. Clarke.

Mr. H. R. Clarke (Chicago, Burlington & Quincy):—The report of Sub-Committee No. 10, Economical Uses for Old Ties which must be Removed from Track and Bridges—A, Treated; B, Untreated, is found on pages 352 and 353 of Bulletin 351. The economical use that may be made of both bridge and track ties, either treated or untreated, that have for some reason been removed from their original location while still suitable for some further use, depends entirely on the condition of the tie so removed.

The Committee calls attention to the opinion expressed that the greatest economy can be realized by leaving a tie in the original location until no further service can be had from it, but since conditions develop which make premature removal necessary the Committee suggests uses that may be made to advantage of such ties.

Attention is directed to the last paragraph of the report and we stress the need for careful study and analysis of the labor cost involved in reuse of old ties, comparing the service that may be reasonably expected from old ties with the almost certain results that would be secured from new ties, the labor involved in handling and use being about the same in each case. The report is submitted as information.

The President:—If there are no questions, it will be so received.

That completes the report on Ties. Are there any questions? There is an expression, "A track is as good as its ties," that acknowledges this Committee's work. They are excused with the thanks of the Association (Applause).

DISCUSSION ON WOOD PRESERVATION

(For Report, see pp. 421–489)

Mr. F. C. Shepherd (Boston & Maine):—The report of Committee XVII—Wood Preservation, is shown on page 421 of Bulletin 352. On page 422, under Appendix A, is the report of the Sub-Committee on Revision of Manual, this report being in two parts. Part 1 submits a table giving Temperatures at Which Fractions should be Cut to Correct Distillation Temperatures for Different Altitudes. This has been produced as a result of the serious differences in results encountered when creosote is distilled at localities differing widely in altitude.

I move that this be accepted for printing in the Manual.

(The motion was put to a vote and carried.)

Chairman F. C. Shepherd:—The second part covers, on pages 424 to 427, tables prepared by a Joint Committee composed of representatives of the American Wood Preservers' Association, the American Railway Engineering Association, and the American Society for Testing Materials, in cooperation with the Bureau of Standards, this being an endeavor to develop suitable correction factors for the changes in the volume and specific gravity of creosote oil with temperature, all of this work having been done at the Bureau of Standards.

I move that this be adopted for printing in the Manual.

(The motion was regularly seconded.)

The President:—Is there any discussion? Are there any remarks?

(The motion was put to a vote and carried.)

Chairman F. C. Shepherd:—On page 427, Appendix B, are given the Service Test Records for Treated Ties. This contains the table of tie renewals per mile maintained on various railroads, revised to include the year 1931. This report also gives results of special test tracks on the B. & O., C. B. & Q., C. R. I. & P., Great Northern, Union Pacific, and the City of Minneapolis Filtration Plant Railway. There is also shown on page 427 the results of a questionnaire relative to the adzing and boring of ties before treatment.

There is one correction on this report. The Santa Fe began adzing and boring in 1911.

This report is furnished as information.

The President:—If there is no objection it will be so received.

Chairman F. C. Shepherd:—On page 439, Appendix C, is the report of the Sub-Committee on Piling Used for Marine Construction. This report gives the present condition of the long-time test pieces in its charge, together with such other pertinent information as has been brought to the Committee's attention.

Also this Committee gives on page 451 the 1932 Report on Test Piles on the Pacific Coast. This report is tendered for information.

The President:—If there is no objection is will be so received.

Chairman F. C. Shepherd:—On page 455, under Appendix D, a report is given by the Sub-Committee on Specifications for Treatment of Air-Seasoned Douglas Fir. This is one of the most important subjects recently assigned to this Committee and the Sub-Committee has done splendid and able work for several years. The report gives the result of a long series of very important tests and at the end submits a general preliminary specification.

If there are any questions to be asked relative to this report, Mr. Belcher, Chairman of the Sub-Committee, would be glad to answer them, it being the hope of the Com-

mittee that we will receive some very constructive, cooperative criticism and thus be able to bring in a final report in another year.

The President:—Does anyone wish to ask Mr. Belcher any questions? If not, the report will be so received.

Chairman F. C. Shepherd:—On page 482, under Appendix E, is the report of the Sub-Committee on Destruction by Termite and Possible Ways of Prevention. I am sure Dr. von Schrenk would be glad to give a short statement in explanation of our Sub-Committee's report.

Dr. Hermann von Schrenk (Consulting Timber Engineer):—The report really speaks for itself. It is simply a continuation of the type of work which the Committee has been doing during past years in connection with the investigation dealing with termite. You will note also that we have included this year, at the bottom of page 483, some notes on the wharf borer.

The Committee wants to point out that although we have included this in the report on termites, the wharf borer is not a termite but belongs to a very much higher group of insects. The reason for including notes on this organism this year is that it apparently had made its appearance in a great many of our harbors. Its actions are still rather mysterious. We have given on page 484 a picture of the creature as it appears in creosoted and untreated piling of wharves on the Gulf and Pacific Coasts, with the idea that we would appreciate very much any information which might be transmitted to us by anybody, not only as to the occurrence of these organisms but a detailed statement as to the damage they have done.

We hope next year to have a progress report on preventive measures which we have indicated in the report this year.

The President:—Doctor, in a few words would you mind telling us the high spots in connection with that fine movie that was presented in New York several months ago?

Dr. Hermann von Schrenk:—At the meeting of the American Society for Testing Materials, held in New York the latter part of December, we were able to secure a very good moving picture film which had been prepared by the associated tar distillers of the various European countries. Owing to the length of that film we regret very much that it did not seem opportune to present it here. That film was remarkable, particularly the section of it prepared by the German UFA Company, in which they had taken underwater moving pictures of marine borers, particularly of two species. They also secured a number of very good moving pictures of various termites and other insect destruction of living trees as well as structural materials. The particularly interesting part to which Mr. Neubert referred was the part showing the destruction by termites, the manner in which they bore into the wood, the manner in which they travel back and forth in the various wood structures. The film is still in America, and if we can come to some arrangement as to licensing with the European manufacturers we hope to be able to show the pictures to the convention at another time.

The President:—Would anyone like to ask the Doctor any questions? This report is submitted as information?

Dr. Hermann von Schrenk:—As information only, yes.

The President:—If there is no objection, it will be so received.

Chairman F. C. Shepherd:—On page 486, under Appendix F, is a report on Methods of Protection of Treated Materials in the Field. This Committee has been at work for the last two years and late last summer completed a preliminary report which called for collaboration with Committee III and Committee VII. There was an unavoidable delay resulting in the collaboration work not being completed. We had a discussion as to whether we would publish the report or not but felt that inasmuch as it was submitted

for information only it be printed, hoping that during the year such criticisms or suggestions as we received would then enable us to complete the report and bring it in for adoption the following year. This is offered as information only.

The President:—If there is no objection, it will be so received.

Chairman F. C. Shepherd:—On page 489, in Appendix G, is a report of a Special Committee appointed to work with others in order to Develop Suitable Tables of Factors of Expansion for Coal-Tar, Petroleum, Creosote Coal-Tar Solution and Creosote Petroleum Mixtures for such Ranges of Temperatures as are of Interest to the Users of Treated Timber.

This Committee's report is the second part of Revision of Manual already adopted, so that this Committee now represents that its report be accepted and recommends that the subject be discontinued.

The President:—If there is no objection, that will be done.

Chairman F. C. Shepherd:—That completes our report.

The President:—Is there any discussion or any question the members would like to ask this Committee? Wood preservation has been known in this country for quite a while and those who have not used it are considered unfortunate.

Wood preservation works back into some problems that many of us do not foresee. It works back into the field of inspection of proper timber and the better manufacture and selection for use. It goes from there to the processing for proper treatment. With proper treatment it gives us quality, which is giving us the great returns we have today.

The Committee is excused with the thanks of the Association (Applause).

I have just been informed in regard to the movie that Dr. von Schrenk mentioned that it was taken in Europe, and that it will be shown in Pittsburgh some time in May (the day has not been set). before the National Society of Bituminous Coal Mining Engineers.

DISCUSSION ON RULES AND ORGANIZATION

(For Report, see pp. 75–79)

Mr. E. H. Barnhart (Baltimore & Ohio):—The report of the Committee on Rules and Organization will be found in Bulletin 349, page 75. The first subject assigned to the Committee was Revision of Manual, and in Appendix A, page 76, the Committee has suggested two revisions.

These revisions were proposed in order to bring the present rules in line with the proposed Bridge Inspection Forms which were to have been presented by Committee XI—Records and Accounts. In line with the report of that Committee yesterday, these forms were not presented. This Committee, therefore, wishes to withdraw its recommendation that this proposed revision be substituted for the present rules, and they will reconsider it during the year in collaboration with Committee XI.

The President:—If there is no objection, the action of the Committee will be carried out.

Chairman E. H. Barnhart:—The second subject assigned by the Committee was Rules for Maintenance of Bridges—Masonry. Mr. Griggs, Chairman of that Sub-Committee, is unable to be present this afternoon. You will find the report of the Sub-Committee on page 77 under Appendix B. These rules were printed last year as information. During the year, in collaboration with the Masonry and Iron and Steel Structures Committees, some changes were made.

The rules as now presented have the approval of Committee VIII—Masonry, and Committee XV—Iron and Steel Structures.

I therefore move that Rules 1150 to 1165, as shown in Appendix B, page 77 of this Bulletin, be approved for printing in the Manual.

Mr. H. M. Church (Chesapeake & Ohio):—On these rules covering maintenance, I should like to ask the Committee for consideration of the elimination of a portion of Rule 1151. I would move the elimination of the last sentence: "If obstructions are caused by a faulty channel, the obstruction should be removed by changing the channel." As that involves engineering work, it is not a subject for maintenance rules.

I should like to have consideration given to removal of the word "any" from Rule 1152, applying both to scouring or undermining. In my opinion, it should not be emphasized that all scouring would be treated as provided by the rule.

The President:—Mr. Church, would you mind going back to Rule 1151? You offer an amendment to that, do you?

Mr. H. M. Church:—I would amend Rule 1151 by eliminating that last sentence.

The President:—Is there any discussion on that?

Chairman E. H. Barnhart:—We could not accept that change without the approval of the Masonry Committee, since they have already approved these rules. We will take the rule back and consider it next year.

Mr. H. M. Church:—We could vote on the amendment.

The President:—We will vote on the amendment. Do you all understand it? It is the elimination of the last sentence in Rule 1151. All in favor of the amendment will please say "aye;" contrary, "no." The ayes seem to have it. Do you want a rising vote on that?

Chairman E. H. Barnhart:—No. We will take that one back.

Mr. H. M. Church:—I am addressing my motion to all rules under Appendix "B". I would recommend the elimination of the word "any" under Rule 1152.

Chairman E. H. Barnhart:—I do not see any objection to cutting out that word because it does not particularly change the meaning of the sentence. We will accept that.

Mr. H. M. Church:—I would move elimination of Rule 1154, as this pertains to engineering and design and I do not see the application for maintenance rules.

The President:—It is in the same category as No. 1151. Do you have any objection, Mr. Barnhart? No? That rule will be taken back.

Mr. H. M. Church:—Under Rule 1155, I would recommend changing the words "have been subjected" to "are subjected," and to eliminate the word "additional" preceding "protection." The latter part of that sentence, "in the form of paving, inverts, apron or curtain walls," is also covering features of engineering and the previous objection is applicable.

The President:—What do you have to say, Mr. Barnhart?

Chairman E. H. Barnhart:—It is the same thing.

Mr. H. M. Church:—Under Rule 1156, eliminate the latter part of the rule reading "and the masonry repaired." From the previous wording those particular words are unnecessary.

The President:—They have had collaboration from other committees. What is your next change?

Mr. H. M. Church:—Under Rule 1157, I move that the word "masonry" preceding the word "foundation" be eliminated, and also the elimination of the last words, "or the structure removed and rebuilt." I would eliminate that portion of it. That is an engineering and not a maintenance feature.

Under Rule 1161, I would eliminate the last portion of the rule, "by installation of drain tile or pipe." There may be other remedies. I would stop with the word "reme-

died." I would eliminate the last part of that. Then it would read: "Inadequate drainage of bridge masonry should be remedied."

I would eliminate the last sentence under No. 1162: "Engineering plans to cover each case will be furnished." That is an engineering feature and not maintenance; that would be implied. I move the elimination of that portion of that rule.

Under 1163, the last sentence covers engineering. I would recommend removal of the entire last sentence: "These areas must be repaired with good quality concrete, observing specifications for repairing deteriorating concrete."

The President:—And the next one?

Mr. H. M. Church:—I would recommend under Rules for Maintenance that No. 1164 be withdrawn as it is entirely an engineering feature. That is all.

The President:—Mr. Barnhart tells me that these have been before the Association for quite a while, and in checking these up it seems to me that you have only the buttons left on. What do you want to do, Mr. Barnhart?

Chairman E. H. Barnhart:—We had better take the buttons back. This Committee, as probably almost every member of the Association knows, is required to collaborate with from one to three committees on every subject. These rules were presented last year as information. They have been out at least two months or more for the Manual. We have received no written criticism whatever. Of course, there is nothing for the Committee to do but take them back and again collaborate with other committees. I would appreciate it if Mr. Church would put his criticisms in writing as we have to put them before other committees.

Mr. H. M. Church:—I would be very glad to do that.

Chairman E. H. Barnhart:—The next subject assigned to this Committee covers the preparation of Rules for Maintenance of Telegraph and Telephone Lines and Appurtenances. The Sub-Committee having in charge the preparation of these rules had an agreement last year to the effect that the Committee of the T.& T. Section would draft from their Manual such rules which properly belong to maintenance of way employees. This, however, was not done, and since the printing of this Bulletin I have received advice from the Committee, through the Secretary of the American Railway Association, to the effect that it was impossible for them to give attention to this assignment but they expect to be able to report some rules to us this year. This subject has been assigned to this Committee for some four or five years.

The fourth subject assigned to the Committee covers Rules for Maintenance of Terminal Structures other than Buildings. This report will be presented by Mr. Kulp, Chairman of the Sub-Committee. He does not seem to be present.

The report of the Sub-Committee is shown on page 77, under Appendix C. It covers Rules 1278 to 1299.

These rules on turntables were printed last year as information and now have the approval of Committee XIV—Yards and Terminals, and Committee XXIII—Shops and Locomotive Terminals.

I move that these five rules be accepted for printing in the Manual.

Mr. A. N. Reece (Kansas City Southern):—I should like to inquire about No. 1299 and ask if it is not already covered in the Manual, under Other Structures, listed under the subheading Oil Houses, being No. 1250. My memorandum reads: "Also in Volume 33, 1931 Bulletin 337, page 83, under heading, Rules for Maintenance of Other Terminal Structures, listed under subhead Oil Houses, Rule 1250, which has been added to the Manual."

Mr. P. C. Newbegin (Bangor & Aroostook):—Rule 1299 states: "Repairs must not be made with open flame lights, and in no case until investigation has been made to determine that there do not exist any oil or gas fumes."

I suggest that that be changed to read: "Repairs should not ordinarily be made with open flame lights," in the first part of that rule.

Chairman E. H. Barnhart:—We will accept the word "ordinarily."

The President:—Have you satisfied Mr. Reece about 1299?

Chairman E. H. Barnhart:—Yes, sir.

Mr. C. W. Baldridge (Santa Fe):—As I read Rule 1299, the latter part of it does not refer to lights at all. It means: "Repairs must not be made with open flame lights and repairs must not be made until investigation has been made to determine that there do not exist any oil or gas fumes."

The latter part of that rule applies to protection of the men, without any lights.

The President:—What do you have to say about it?

Chairman E. H. Barnhart:—That is true. I don't see any difference in the meaning whether the word "ordinarily" is accepted or left out. However, the Committee is willing to accept the word.

Mr. C. W. Baldridge:—It appears to me that the word "ordinarily" should not go in there. Repairs should never be made with open lights in repairing gas tanks.

Mr. P. C. Newbegin:—In some cases it would be impossible to make the repairs in the absence of fumes or gas. They are there when repairs are to be made.

The President:—Would you want to make an amendment to put that word in or leave it out?

Mr. P. C. Newbegin:—I would offer an amendment to the first clause in Rule 1299 so that it will read: "Repairs should not ordinarily be made with open flame lights."

(The motion was put to a vote and carried.)

Chairman E. H. Barnhart:—The next subject assigned to the Committee was: "3. Titles employed to designate positions of corresponding rank in Maintenance of Way Service subordinate to that of Division Engineer, recommend appropriate titles for position known as 'Assistant Engineer' in all departments, considering the duties involved."

Mr. Brooke, the Chairman of the Sub-Committee is not present, but the report will be presented by Mr. Warden.

Mr. R. E. Warden (Missouri Pacific):—The Committee has given considerable study and analyzed very thoroughly the information obtained through a questionnaire last year and presents for information data shown in Appendix D, with the special request that members of the Association who are interested in clearing up this very confusing use of the title give earnest thought and consideration to the recommendations and communicate with the Committee during the ensuing year. A large number of replies would indicate a widespread interest in this very interesting subject and better enable the Committee to make definite recommendations for printing in the Manual.

This will be found in Appendix D on page 78 and is printed as information.

The President:—If there is no objection, it will be so received.

Chairman E. H. Barnhart:—The last subject assigned to the Committee covers Rules for Fire Prevention as Applying to Maintenance of Way Department. Mr. Hayes, Chairman of the Sub-Committee, will present the report.

Mr. H. C. Hayes (Illinois Central):—Assignment No. 4, Rules for Fire Prevention as Applying to the Maintenance of Way Department, collaborating with the Railway Fire Protection Association and National Board of Fire Underwriters.

The Committee offers as information in Appendix E a number of rules on fire prevention. The rules offered last year for information have been carefully gone over

and revised by the Committee and these rules have the approval of the National Board of Fire Underwriters. The Committee hopes to be in position next year to secure the approval of all interested bodies and be able to present a recommendation for approval and printing in the Manual.

Since this subject was assigned to the Sub-Committee, there have been some objections made by members of the Association on the ground that fire prevention should be handled by some other department or bureau other than the maintenance of way department. The Committee, after canvassing the situation, are of the opinion that the standard practice of a majority of the railroads represented in this Association make fire prevention a duty of the maintenance of way department, and we have developed rules shown in Appendix E as a result.

The rules as presented to you in Appendix E, page 79, represent the first draft and will, no doubt, require considerable revision before the Committee feels that they will be justified in presenting these rules for the Manual.

The Committee will appreciate any criticism or suggestion in writing from the members of the Association so that we may consider them in light of our assignment. The rules are offered as information.

The President:—Are there any questions? If not, they will be so received.

Mr. R. C. Bardwell (Chesapeake & Ohio):—On page 76 of Bulletin 349, Committee XII states that proposed fire prevention rules for Maintenance of Way officers shown in Appendix E on page 79 are offered as information, and hopes that it will be in a position to present a recommendation next year for printing in the Manual.

With this in view, it is believed that a few remarks are warranted as there is some question as to whether the Manual should contain recommendations incorporating mandatory regulations which, if carried out literally, would tend to make fire prevention inspectors out of some very valuable maintenance officers and interfere with their regular duties.

Representing railway water service, I wish to call attention to the fact that under the last paragraph on page 79, headed "Supervisors of Water Service", proposed rules 423 and 424 are impractical and not in line with proper duties and responsibilities of Water Service Supervisors, and proposed rule 425 is not complete.

Many of the pumps and fire lines on railroad property are located within shop grounds under the jurisdiction of the Mechanical Department over which Water Service Maintenance forces have no control. In addition, pumps and pipe lines are installed, operated, and maintained by Supervisors of Water Service under instructions from the management and the question of sufficient volume to quench any fire on the property is a matter to be determined by others before installation is authorized. This rule could well be confined to the operation and maintenance of fire pumps and fire lines under their jurisdiction.

The question of fire hydrant maintenance might best be handled under a separate rule and include provision for adapters where size and threads on nozzles do not fit the nearest municipal fire department facilities. Also there is the matter of prompt repairs to any defects noted or reported by Fire Prevention Inspectors.

Proposed rule 424 should be eliminated, as the question of connections to municipal fire mains is a matter of policy to be determined by others.

The laws on cross connections and possible damage which may be caused by improper connections are such that the question of connections to any municipal water mains must be given very careful consideration.

Proposed rule 425 could well be expanded to include road mechanics or repairmen, and pumpers who should all observe fire prevention rules.

If Committee XII is not familiar with the duties of Water Service forces, I am sure that Committee XIII—Water Service, will be pleased to furnish information at any time.

As this report is not in satisfactory shape at present, it is recommended that this subject be referred back to the Committee for further study and report.

The President:—That is what the Committee proposes to do, Mr. Bardwell, and the Committee would be glad if you would write them fully in regard to these rules. They would gladly accept your suggestions. The subject will be continued and the Committee on Outline of Work will take it under advisement.

This finishes the report of the Committee on Rules and Organization. You cannot run a railroad satisfactorily and efficiently unless you have an organization, and you cannot make an organization function unless you have rules. This Committee needs food for thought from the members, and on their behalf I suggest that you give them all the food for thought that you can so that they can coordinate and cooperate in all their work.

The Committee is excused with the thanks of the Association (Applause).

DISCUSSION ON ECONOMICS OF RAILWAY OPERATION

(For Report, see pp. 533–575)

Mr. J. E. Teal (Chesapeake & Ohio):—The report of the Committee on Economics of Railway Operation will be found on page 533 of Bulletin 353. Your Committee reports progress on all assignments except No. 2 and No. 5. Assignment No. 2, Methods for Obtaining a More Intensive Use of Existing Railway Facilities, with particular reference to securing increased carrying capacity, which your Committee presents as Appendix A, deals with due regard to reasonable increases in capital expenditures consistent with traffic requirements. This is designated as Part (b) of the assignment.

In the absence of Mr. Mannion, Chairman of the Sub-Committee, I will briefly present Appendix A, which is found on page 534. Before proceeding, I wish to call attention to two corrections. The first is in the last line at the bottom of page 540, where the words "heavier power" should read "changes in power." The second typographical error is on page 545, in the tabulation near the bottom of the page, where the word "train" in the last two lines should be "hours."

Your Committee has presented reports during the past few years showing the effects of various changes in operating conditions on freight train performance, embracing traffic density, length of engine district, double tracking, passenger train operation, supervision, heavier power, automatic signals, centralized traffic control, and converting double track into single track.

The report this year specifically relates to methods of forecasting the improvement in train operation on a single track railroad equipped with short sections of double track with spring switches and CTC controlled manual block.

The study embraces a freight train district of about 123 miles in length, described on page 534, the present track plan and profile of which are shown in Fig. 1, page 535. An outline of operation, together with statistics showing the freight train performance during a period of years prior to and including 1932 will be found on page 536, from which it will be noted that the greatest traffic density occurred in 1927 which was substantially maintained until 1930 when it decreased on account of general business conditions. Additional second track and other improvements, installed between 1924 and 1929, were largely responsible for an improvement of 22 per cent in train performance during that period.

Studies were then made for installing about 62 miles of double track costing over $5,000,000. This expenditure could not be justified and attention was then given to rearranging passing sidings to form short stretches of double track with spring switches and CTC controlled manual block.

The factors to be considered in comparing the present track layout and method of train operation with the proposed track layout and CTC controlled manual block method of train operation include:

1. Present and proposed track and signal layout.
2. Expenditures necessary in connection with track changes.
3. Effect of proposed track plan on track and other maintenance, taxes, train operation, cost of transportation, and track capacity.
4. Comparison of present and proposed methods of freight train movements.
5. Annual savings and return on expenditures.

As I have just stated, the present track plan is shown in Fig. 1. The section of line selected for CTC controlled manual block operation embraces about 84 miles, of which 62 miles are single track, with 14 passing sidings. The train movements are handled by timetable and train orders with manual blocking, the blocks varying in length from 2 to 17 miles.

Fig. 2 on page 539 shows the proposed track and signal plan, details of which are described on page 538. The plan provides for removal of eight of the existing passing sidings, extending and converting five to double track sections about three miles in length, and extending the present double track about two miles. The plan provides for eight double track sections in the 84-mile territory, which is accomplished by requiring about 6,000 feet of additional track.

The expenditures, aggregating $1,000,000, necessary in connection with track changes are shown on page 540.

The effect of operating under the proposed track and signal plan is outlined in detail on page 540 to page 545, which page also includes diagrams and tables used in determination of the result.

Attention is particularly called to Fig. 4 on page 542, which is a typical train movement diagram, of a portion of the line, between the hours of 7 A.M. and 6 P.M. This diagram shows the sections of the 24-hour train movement which are plotted from the train sheets on a time and distance scale. All the delays are recorded, showing their causes. With this graphic information showing actual train performance, the next step is to determine what portion of the train delays will be eliminated under the proposed plan of operation. This may be accomplished by redispatching the train movements, by drawing new lines and advancing the trains to new meeting points, where the analysis indicates that such would happen with additional facilities for receiving information and putting out orders.

This method of redispatching is shown graphically by Fig. 5 on page 543 in the simplest form. The result of the study for a 24-hour period is tabulated in Table No. 3, page 544. The study should extend over a period of 10 or 15 consecutive days to include the performance of 100 or more trains under the most favorable operating conditions.

The general procedure has been outlined by this Committee and published in the Proceedings, Vol. 32, page 670, under the heading, "Log of Freight Train Performance."

Fig. 3 on page 541 shows the freight train performance during the years 1924 to 1932, inclusive, together with the anticipated freight train performance under CTC controlled manual block operation with the 1930 business. This performance is represented by Lines A-D. Point A is taken as the minimum number of hours per 100 train miles.

Line A-D is plotted to represent a saving of 1.8 hours per train, being the result of the train movement study just described, and a 15 per cent increase in train load compared with 1930 operation.

Credit for an increase in train load will depend upon a number of conditions, including traffic density and the number of train stops that may be eliminated under the proposed method of operation.

A computation of the train miles and train hours that will be saved is shown on page 545. If credit is taken for an increase in train loading, the decrease will be: Train miles, 13 per cent; train hours, 34 per cent. If credit is not taken for an increase in train loading, the decrease in the number of train hours will be 24 per cent.

The justification of proceeding with the proposed plan will depend on the cost per train mile or per train hour before and after its installation.

The conclusions are found on page 546, reading:

"Where the distribution of traffic on existing lines results in considerable overtime under timetable, train order, and manual block system, consideration should be given to a rearrangement of tracks by eliminating passing sidings, providing short sections of double track, and installing a system of CTC controlled manual block for directing train movements by signal indication, which will provide:

"1. Reduction in overtime by eliminating excessive delays and stops at meeting and passing points, shorter block lengths, reduction in running time, and a reduction in the number of water stops.

"2. Increased track capacity.

"3. Increased train load.

"4. Increased safety in train operation.

"5. Increased flexibility of operation by directing train movements by signal indication.

"6. Reduction in transportation expense."

Your Committee submits this report as information and recommends that the subject be continued.

The President:—Are there any questions? If not, the subject will be so handled.

Chairman J. E. Teal:—Assignment No. 5, Appendix B, Methods for Determining the Most Economical Train Length Considering all Factors Entering into Transportation Costs, will be presented by Mr. L. S. Rose, Chairman of the Sub-Committee.

Mr. L. S. Rose (Peoria & Eastern):—The report on this subject is found in Bulletin 353, page 546. The subject has been before the Committee for several years to plague them; you will find in the report that we have taken liberties with train lengths. We have gone to a tonnage rating. A method has been worked out by Mr. Kimball of this Committee, assisted by Mr. Snyder, for determining the best tonnage rating based upon the horsepower of the engine. Partial tables are submitted for engines with a certain percentage of their weight on the drivers. The tables are not complete; but for those engines that fall within these ratios you will find that this is a better method for the rating of trains than some that are now in use.

The tables give the maximum tonnage rating, depending upon the horsepower, and the maximum gross ton miles per train hour. The report is submitted as information and we request that the subject be continued.

The President:—It is good information, too. Are there any questions you would like to ask Mr. Rose? If not, it will be so received.

Chairman J. E. Teal:—That concludes our report, sir.

The President:—Would you like to ask this Committee any questions?

Past-President Edwin F. Wendt:—Before the Committee is excused, I desire to comment on the increase in the efficiency of railway operating during the past twenty-

five years. It seems to me that the American Railway Engineering Association may properly take some credit for what has been accomplished.

The depression in the railroad business is probably the worst in one hundred years. The stock market quotations of 1932 indicate that railroad stocks had declined to about 10 cents on the dollar. Railroad people have been much discouraged. They wonder what the future has in store, and their minds are influenced more or less by the inroads of the motor truck, inland waterway, and aeroplane, on railway revenues.

In times of storm it is a good plan to review the past, and I am reminded that at the first Annual Convention of the A.R.E.A., President John F. Wallace remarked that "The record of the past is the only safe guide for the future." Let us briefly review the past history of railroads during depressions.

I do not have statistics covering the depressions of 1837, 1857, and 1873, but it is generally admitted that the depression of 1932 was the worst in the history of the railroad business. However, since the formation of the Interstate Commerce Commission in 1887, we have reliable statistics. Previous to 1932 it is interesting to note that during depressions the railroads did not suffer as severely as industrial enterprises, whereas in the depression of 1932 the railroads suffered reduced earnings almost exactly the same as industrial companies. The decline in industrial production in 1932 compared with 1928–'29 was 50 percent, and this is substantially the reduction suffered by railroad companies.

The decline of gross operating revenues of railroads from their previous maximum was:

1894—12 percent	1915— 6 percent
1908— 8 percent	1921—11 percent
1932—50 percent	

The question naturally arises why did the railroad business decline the same as industry in 1932, whereas in previous depressions the decline was much less. It seems to me that there are a number of reasons, two of which are: (a) the rise and growth of transportation by highways, waterways, pipe lines, and airships, and (b) the decline in immigration from 1,000,000 per year to practically none. If the immigration had not been stopped, there would have been probably 15,000,000 more people in this country to be fed, clothed, housed, and amused.

The passenger business has been adversely affected by the motor, particularly by the private automobile. It is probable that there will not be any net income from the passenger business within the next few years, but it may well be that it will earn its own way. If the passenger business is operated without loss, as may reasonably be expected, the future net railway operating income will be derived from the freight business.

The railways have experienced hard times in the past, and have successfully adjusted themselves to new conditions by increasing their efficiency. The increase in efficiency during the past twenty years has been remarkable. Labor and materials more than doubled in price, and taxes trebled. The operating ratio of Class I Roads increased only 2 per cent between 1913 and 1928. It will be remembered that the World War did not break out until 1914, and the year 1913 is representative of pre-war prices, whereas the year 1928 is representative of post-war prices. The mileage of railroads has remained almost stationary during the past twenty years, the total mileage being 250,000. There has been only a small increase in capitalization during the past twenty years. In 1913 the total railway capital was $20,000,000,000 in round numbers, and in 1931, $22,000,000,000., including non-operating subsidiaries. The per cent of debt to total capital has remained almost uniform at 56 percent from 1913 to the present time.

Therefore the amount of stock is 44 percent of the total capitalization. In view of the great improvement in the physical properties during the past ten years, it is significant that the capitalization has increased but little.

It is interesting to note that the Interstate Commerce Commission introduced an exhibit at the hearing in Ex Parte No. 103, containing significant data on valuation as of December 31, 1930, summarized as follows:

COST OF REPRODUCTION NEW AT PERIOD PRICES

Class I Railroads	$26,864,303,934
Class II Railroads	497,771,125
Class III Railroads	122,941,947
Switching and Terminal Railroads	571,458,946

COST OF REPRODUCTION NEW AT SPOT PRICES

Class I Railroads	$26,033,317,372
Class II Railroads	482,500,068
Class III Railroads	119,269,339
Switching and Terminal Railroads	554,570,700

ORIGINAL COST TO DATE OF ALL PROPERTY, EXCEPT LAND, OWNED AND USED BY STEAM RAILROADS AS OF DECEMBER 31, 1929

Total amount $22,092,107,618

Please note that land is omitted, and Original Cost was estimated on the basis of 1914 prices, plus actual costs since that date.

ESTIMATE AS OF DECEMBER 31, 1930, OF THE VALUE OF LANDS AND RIGHTS USED BY STEAM RAILROADS

Grand Total ....$3,778,248,076.

Working Capital, including Material and Supplies, used by steam roads as of December 31, 1930—

Grand Total ....$503,161,000.

Cost of Reproduction New, plus Present Value of Land, plus Working Capital, as of December 31, 1930:

Grand Total ....$32,337,885,000.

The Commission deducted about 20 percent for Accrued Depreciation, thus leaving $26,500,000,000 (round numbers) as the Cost of Reproduction less Accrued Depreciation of the railway system of the United States, including land and working capital.

The Original Cost to Date estimated by the Commission plus Present Value of Land, plus Working Capital, is $26,970,728,000.

Thus it appears that the Commission's Valuation data has performed one very important service in showing that the roads as a whole "are substantially undercapitalized", and that the Commission's Valuation figures vary but little from the railroads' own book values.

The so-called Coolidge Committee recently arranged with the Brookings Institution to prepare a report on the railroads, and a report has just been issued. It was prepared by Harold G. Moulton and fourteen associates. The publication entitled "The American Transportation Problem", page 417, contains a significant statement in support of my view that the railroads are undercapitalized from 20 to 25 percent. Dr. Moulton reached the following conclusion:

"It will be recalled that the belief that the railroads were greatly overcapitalized was one of the reasons which led to the Valuation Act of 1913. * * * It will be seen that the roads as a whole are substantially undercapitalized, and that the Commission's Valu-

ation figures vary but little from the railroads own book values. While many roads were undoubtedly overcapitalized in earlier days, surplus earnings have been put back into the properties in sufficient amounts to absorb all of the water and to provide a substantial margin of investment over and above the par value of outstanding securities."

The average rate of railway wages has increased much faster than gross revenue. The average wage rate in the five years previous to 1930 was nearly two and one-half times that of the pre-war period between 1905 and 1910.

The railroads have substantially reduced their cost of operation per unit of traffic since the World War.

Operating Expenses in per cent of Gross Operating Revenues were:

	1905–1910	1911–1916	1924–1929
Gross operating revenue	100 per cent	100 per cent	100 per cent
Operating expense:			
Way and structures	13 per cent	13 per cent	14 per cent
Maintenance of Equipment	15	17	20
Transportation	35	35	34
Traffic, miscellaneous and general expenses	4	5	6
Total	67	70	74
Taxes	3	4	6
Total operating expenses and taxes	70	74	80
Railway operating income	30	26	20

The depression of 1907 occurred in the first period. The depression of 1914 occurred in the second period, and the boom of 1929 occurred in the third period.

The statement indicates that Maintenance of Way and Structures remained almost stationary with respect to Gross Operating Revenues, notwithstanding the fact that the wage rates in the boom period were almost two and one-half times the wage rates paid in the first period 1905–1910. This is an interesting fact, and indicates how successful Engineers were in overcoming difficulties incident to the great rise in the cost of material and labor. It will be remembered that the wholesale commodity index reached 220 in May, 1920, in contrast with 100 in the year 1913. Prices of material and wages more than doubled, but the Maintenance of Way Engineer by reason of improvement in efficiency was able to maintain his road without increase in the per cent relationship of Maintenance of Way and Structures Expense to Gross Operating Revenue.

(NOTE—These figures were taken from the Wall Street Journal.)

Statistics indicate that in the past ten years the diversion of traffic from railroads to trucks has progressed very slowly, and it is reasonable to expect that the diversion will not increase in the future at the rate of the past because the main highways have been improved. Trucks are likely to be restricted more and more in the future, and the railroads are certain to make every effort to retain their business through fast service, store-door delivery, and the coordination of service between rail, highway, water, and air.

The general opinion is that 1932 marked the low point in the depression. There was a 50 per cent reduction in gross earnings of railways. When prosperity returns, the question is, will the railroads be able to recover all that has been lost. It is probable that a certain percentage of traffic has been permanently diverted to the highways. However, this diversion is gradually reaching its maximum, and an analysis of the growth of railway freight traffic during the last fifty years indicates that traffic will regain by 1942 the normal trend which was established previous to the present depression. It will not be surprising if railroad freight traffic five years hence equals, or exceeds, its previous peak. The population of the United States is increasing at the rate of over 1,500,000 per

year, and with the normal growth of traffic, and the increased efficiency of operation which may be expected, there is every reason to anticipate that the railroads will again become prosperous.

The American Railway Engineering Association has recently completed its thirty-fourth year, and the work of its various Committees has contributed in large degree to the development and increased efficiency of American railroads. Special commendation is due the Committee on Economics of Railway Operation, as well as all other committees of the Association, for the splendid work which they have done.

The President:—In that same connection, this Committee has worked not only in its own field but it has to deal with every branch in the transportation field. It has always done good, constructive work. I believe that only a few years ago a lot of Executives of railroads felt that they could go ahead and apply the principles laid down by this Committee, and that has been very effective.

The Committee is excused with the thanks of the Association (Applause).

DISCUSSION ON ECONOMICS OF RAILWAY LABOR

(For Report, see pp. 101–124)

(Vice-President W. P. Wiltsee in the Chair.)

Mr. Lem Adams (Union Pacific):—Economics of railway labor, in its broadest sense, is about the most important question before railroad officials today, as all of us are constantly confronted with the problem of what further can be done to decrease the cost of railway maintenance. It is the hope of this Committee that some of the subject matter discussed in the report today will be of value to you in solving your individual problems.

The report of the Committee is found in Bulletin 349, pages 101 to 124, inclusive. There is no Revision of the Manual, except as will be presented in connection with the report of Sub-Committee 9.

The second assignment is Analysis of Operations of Railways that have made Marked Progress in the Reduction of Labor Required in Maintenance of Way Work. Mr. Parant, Chairman of the Sub-Committee, is not able to be with us today. However, the Committee reports progress on this assignment, as Mr. Parant and his Committee have done a lot of work on this subject in the past two or three years, and during 1932 a very comprehensive report containing splendid subject matter was submitted.

On Subject 3, Effects of Recent Developments in Maintenance of Way Practices on Gang Organization (such as Use of Heavier Rail, Treated Ties and Labor-Saving Devices, which make Practicable Small Section Forces, and Conducting the Major Part of Maintenance Work With Extra Gangs), Mr. Schwinn, Chairman of this Sub-Committee, could not be present. However, the Sub-Committee has collected considerable information in addition to that reported last year in Vol. 33, giving complete description of practices in effect on five railroads. The present report supplements the information previously given and includes a résumé of practices followed on four railroads.

Under present conditions you will find it interesting to review these reports, and I am going to take the liberty of reading that part outlining the practices in effect on the Chicago, Burlington & Quincy Railroad.

"As the result of improved rail, tie, ballast and drainage conditions and the use of labor-saving devices, this railway has been able to introduce a complete reorganization of its track maintenance forces. Under the new plan, the section gang continues as the primary unit in the maintenance organization, but the average length of sections was increased from about 8 miles to 12 miles, thus accomplishing a reduction of one-third in the number of sections.

"The section foremen, however, are relieved of the duty of daily track patrol, this function being performed by track supervisors (a new position) each of whom has jurisdiction over about six sections, or 75 miles, and who report to and work under the direction of the Roadmaster. This plan has also permitted increasing the length of Roadmasters' territories from one engine district to two engine districts, or about 225 miles, this generally covering three Supervisors' territories.

"The plan was applied progressively, one operating division being covered at a time. By the close of 1931 the new plan was in effect on all lines west of the Missouri River and a part of the lines east, and the results were so favorable that it was expected to continue the reorganization through 1932 to include the entire system. The plan has permitted increasing the number of men per section and by improved supervision, has eliminated to a large extent what would normally be unproductive time. The results up to date have been very satisfactory and apparently are accompanied by appreciable economies. A full account of the Burlington plan may be found in the January 1932 issue of Railway Engineering and Maintenance."

Under Subject 5, Programming of Bridge and Building Work, Mr. Botts, Chairman of this Sub-Committee, has accumulated a lot of useful information. However, he wishes to report progress only.

Under Subject 6, Revised Plans for Outfit Cars for Maintenance of Way Department Employees, Mr. Magee, as Chairman of this Sub-Committee, has worked out a number of plans. However, he is not ready to complete his report and we ask that this be carried over until next year.

Subject 7, Economics of Methods of Weed Killing. This subject has been with us for several years, but we still report progress only.

Subject 8, Use of Motor Trucks in Maintenance of Way and Structures Work. Mr. Stout, Chairman of the Sub-Committee, will present this report.

Mr. H. M. Stout (Northern Pacific):—The report of your Sub-Committee appears on page 107 of Bulletin 349. The data was collected a considerable while ago so if any of the members present find their roads are not correctly listed as to the number of machines that are being used, the reason for that will be due to the fast changes that are being made in this class of equipment. The cost of operating these machines or the economies realized by their use vary. The returns which we received in the collection of data upon which the report is based varied from a road which found no economy in the use of motor trucks to other roads that claimed the saving of the price of a motor truck per year.

The motor truck is not useful in its present form on the present maintenance of railroads in all maintenance work, but the classes of work to which they are adapted have been mentioned in the report.

The report is given you for information.

Vice-President W. P. Wiltsee:—It will be so received.

Vice-Chairman Lem Adams:—Subject 9, Gang Organization and Methods of Performing Maintenance of Way Work, Including Revision of Time Studies now in the Manual. Mr. Howe will present this report.

Mr. C. H. R. Howe (Chesapeake & Ohio):—In the preparation of this report particular attention has been given to the subject of laying rail. It appears in the Manual on page 114. The Committee's report on rail laying schedules now includes the 39-foot as well as the 33-foot rails. Provision is likewise made for the increased number of ties now used on many roads.

It is the opinion of the Committee that any attempt to set up schedules for rail laying by mechanically equipped gangs would be abortive at this time as much of the equipment is only in the development stage. However, for your information, the Committee presents as illustrative of progress that is being made, the organizations employed and

the results obtained on three railroads where the type of track makeup is somewhat varied.

Your Committee does not believe that time studies and work schedules are suitable material for inclusion in the Manual as they are more or less of transitory interest and are subject to progressive modification.

It is our opinion that such information is more suitable for publication in the Proceedings. It is the Committee's recommendation that the subject-matter in the Manual beginning with Exhibit A on page 1449, to and including the first three paragraphs on page 1466, be withdrawn.

The Committee recommends that this report be received as information and the subject continued.

Vice-President W. P. Wiltsee:—We should have a motion on the revision of the Manual.

Mr. C. H. R. Howe:—The Committee makes that as a motion, that the subject-matter in the Manual beginning with Exhibit A on page 1449, to and including the first three paragraphs on page 1446, be withdrawn from the Manual.

Vice-Chairman Lem Adams:—I second the motion.

Vice-President W. P. Wiltsee:—You have heard the motion. Is there any discussion?

(The motion was put to a vote and carried.)

Vice-Chairman Lem Adams:—Subject 4, Standard Methods for Performing Maintenance of Way Work for the Purpose of Establishing Units of Measure of Work Performed. Since this subject has been assigned to this Committee at various times, beginning with the year 1920, the report given at this time is largely a brief of previous reports.

In 1925 (page 930, Vol. 26) the report of the Committee contained a discussion of the following principal features of the plan previously recommended:

1. Standard methods and time schedules for each item of work.
2. Instructions to foremen to enable them to submit accurate reports of performance.
3. Closer supervision by means of planning and dispatching the work in advance.
4. Sample forms for the notation of records and performance for comparison of results.

It is the opinion of the present Committee that the two outstanding features to be considered are "Standard methods and time schedules for each item of work," and "Closer supervision by means of planning and dispatching the work in advance."

In meeting the conditions now confronting the railways it has been found that we can greatly curtail or dispense with many of the operations formerly considered essential in performing maintenance of way work. However, the time schedule still remains an important item, since without definite schedules, we will work with "hit-and-miss" methods that are not conducive to economy. Likewise, planning and dispatching are essential if we are to secure maximum efficiency, as any haphazard method of performing work, even on a small sub-division, will result in important items of work being delayed or omitted from the program.

Various reports of this Committee in the past have set up a table of equated track values, which is very useful in the establishment of section limits, and for ready reference the table of equation is printed in the report, this being the same table that we have been using for years:

One mile of first main track equivalent to:

1.15 miles of second main track
1.33 miles of third or fourth main track
2.00 miles of branch line track
2.00 miles of passing and thoroughfare track
3.33 miles of yard tracks
12 main line switches
20 sidetrack switches
10 railroad crossings
12 city street crossings
25 to 50 country road crossings
½ mile of track pans
4 miles of ditches

In applying these values, due consideration must necessarily be given the volume of traffic and the varying condition of the track involved. Traffic density is, of course, the destructive agent on any piece of track, and the condition of the rail, ties, and ballast are important factors that must be considered at all times in the assignment of track forces.

In the 1924 report of this Committee the following conclusions appeared:

"(1) The making of time studies and the comparison of performance of an individual gang with a standard increases the efficiency of the gang under observation and of other gangs which are made acquainted with results.

"(2) The general use of standard methods and units of measure of performance on divisions and districts of a railway has resulted in increasing the efficiency of track forces."

The Committee's final report in 1926 concluded that:

"It is not possible to determine a fixed unit of cost of maintenance of way and structures accounts for any unit of property, such as the equated mile, or for any unit of use, such as thousand car miles. It is further the conclusion that it will be impossible to determine upon such unit of cost at any future time unless all railways were to adopt the use of standard materials and standard practices, and even then there would exists differences reflecting the differences in location, climatic conditions and physical construction."

Your Committee concurs in the above conclusion at this time.

This concludes the report of the Committee, Mr. Chairman.

Vice-President W. P. Wiltsee:—Is there any discussion on the report of this Committee? I should like to ask the Committee what disposition they desire to make of these conclusions? Are they submitted as information?

Vice-Chairman Lem Adams:—It is submitted as information only.

Vice-President W. P. Wiltsee:—It will be so received. This Committee has again submitted to us a report of real value and we will now relieve them with our thanks for their good work (Applause).

DISCUSSION ON WATER SERVICE AND SANITATION

(For Report, see pp. 81–100)

(Vice-President W. P. Wiltsee in the Chair.)

Mr. R. C. Bardwell (Chesapeake and Ohio):—The report of Committee XIII—Water Service and Sanitation, is presented in Bulletin 349, pages 81 to 100 inclusive.

Revision of the Manual is considered under Appendix A, page 82, and attention is called to the two charts, tables No. 1 and No. 2 printed on pages 83 and 84, showing detailed dimensions and weight of various classes of standard cast iron pipe which were inadverently omitted at time of the adoption of the "Specifications for Cast Iron Pipe and Special Castings," which appear on pages 902 to 907 inclusive, of the 1929 Manual.

These specifications are not complete without these standard tables, and it is therefore moved that the Association approve the publication of these tables No. 1 and No. 2 in the Manual with the balance of the cast iron pipe specifications.

Vice-President W. P. Wiltsee:—It has been moved and seconded that the tables mentioned be included in the Manual. Is there any discussion?

(The motion was put to a vote and carried.)

Chairman R. C. Bardwell:—The only other suggestion is for correction of error in symbol for dimension of hoop lugs shown on page 940 of the 1929 Manual which should be "Z" instead of "2", which it is presumed the Secretary will handle.

Your Committee wishes to report "Progress" on the second assignment, "Pitting and Corrosion of Boiler Tubes and Sheets", and it is hoped that report can be presented next year.

The report on assignment No. 3, "Methods and Value of Water Treatment" with respect to estimating and summarizing possible savings effected, is given in Appendix B, and will be presented by the Sub-Committee Chairman, Mr. R. E. Coughlan.

Mr. R. E. Coughlan (Chicago & Northwestern):—The report of this Sub-Committee is given in Appendix B, page 85 in Bulletin 349.

During the past year your Committee investigated the methods of water treatment on all of the Class I railways in the country with a view of obtaining all information available from which a monetary value might be calculated on the improvements obtained.

It was found that five recognized methods of water treatment were in use, all of which would give excellent results if properly installed and supervised. There is no general fixed rule as to which of these methods are most suitable without a thorough preliminary survey being made in which survey the Operating and Motive Power Departments should be freely consulted.

The information given in our report is the result of this year's investigation and shows conclusively that all forms of water treatment result in a gratifying improvement, shown directly in decreased boiler maintenance, extended mileage of runs, elimination of locomotive delays and failures and actual extensions of time in regard to shoppings required by federal law every four years.

For want of a better measuring stick of a monetary value it was decided to maintain the figure of 13 cents per pound of incrusting solids removed as being the gross value to be obtained in methods of complete treatment.

This report is offered as information.

Chairman R. C. Bardwell:—Although the cost of operation and maintenance of water stations is only approximately 1.0 per cent of railway operating expenses, the aggregate amount is quite considerable and as the effect of suitable water at proper loca-

tions is an important factor in economical railway operation, it is advisable that suitable cost records be maintained to properly plan improvements. Reports on Assignment No. 4 covering this subject appears in Appendix C and will be presented by Sub-Committee Chairman, Mr. E. M. Grime.

Mr. E. M. Grime (Northern Pacific):—This report is found on page 87 of Bulletin 349. Even though now well established on most railways, the Water Department is still in its infancy. It is constantly proposing changes in existing facilities and improvements in water conditions which are necessary to make it possible for the Mechanical Department to provide the increased speed and reliability demanded by changing operating conditions. The progress made is of particular interest to railway officers and it therefore seems desirable that an annual summary be prepared to show not only the actual cost of pumping water but, in those cases where conditioning of this water becomes necessary, that feature also be included in order that the results under varying conditions may be seen at a glance. Such data is not only useful to Mechanical and Operating Department officers but is also necessary in the Water Department for the purpose of keeping a check on softening plant operation and observing the possibilities for further improvement in pumping facilities.

We recommend the use of Form 1301 revised, shown on page 599, Proceedings of 1932, covering a Monthly Pumping Station Report, revised, as found necessary in individual cases, and Form 1302 revised, shown in the 1931 Proceedings, for corresponding annual report.

This report is presented as information.

Vice-President W. P. Wiltsee:—It will be received as such.

Chairman R. C. Bardwell:—Final report on Assignment No. 5, "Development of Deep Well Pumping Equipment," appears in Appendix D, and will be presented by Sub-Committee Chairman, Mr. J. P. Hanley.

Mr. J. P. Hanley (Illinois Central):—The report on Deep Well Pumping Equipment appears on page 88 of Bulletin 349.

Previous reports on certain phases of deep wells and deep well pumps were presented to this Association by the Water Service Committee in 1913, 1915 and 1926. The present report reviews the subject briefly and mentions recent improvments in this class of equipment.

Steam head pumps, double acting cylinder pumps, two-plunger pumps, deep well turbine pumps and air lifts are discussed. It appears that deep well turbine pumps are replacing other types of apparatus for the general run of installation. The use of air lifts is still advisable in special cases, as mentioned in the report, where conditions are not favorable for the strictly mechanical types.

The conclusions are five in number and appear on page 90. Permission is asked to correct an error in the third line from the bottom of Conclusion No. 4, showing the efficiency of air lifts. This should read "25 per cent to 30 per cent," instead of "25 per cent to 40 per cent," as it now appears.

With this correction the report is offered as information.

Vice-President W. P. Wiltsee:—It will be so received. Is there any discussion on this report? If not, proceed.

Chairman R. C. Bardwell:—Your Committee desires to report progress on Assignment No. 6, "Design and Maintenance of Track Pans for Locomotive Water Supply", and it is hoped that final report will be presented next year.

Progress report on Assignment No. 7, "Standard Methods for Analyses of Chemicals Used in Water Treatment", appears in Appendix E, and will be presented by Sub-Committee Chairman, Mr. R. M. Stimmel.

Mr. R. M. Stimmel (Chesapeake & Ohio):—The report of Sub-Committee No. 7, on Standard Methods for Analyses of Chemicals Used in Water Treatment, appears on page 91 of Bulletin 349. Methods for analysis of hydrated lime and soda ash are presented this year. A complete analysis of these chemicals is not necessary to determine their reaction value in water treatment. The methods only give the determination of the percentage of those constituents which are of value in water treatment and which are covered by specifications. The methods as reported appear to be the shortest and most correct available.

It is recommended that these methods be adopted for publication in the Manual.

Chairman R. C. Bardwell:—I move that the methods given on page 91 be adopted for publication in the Manual.

Vice-President W. P. Wiltsee:—It is moved and seconded that the information shown on page 91, Analysis of Soda Ash and Analysis of Hydrated Lime, be included in the Manual. Is there any discussion?

(The motion was put to a vote and carried.)

Chairman R. C. Bardwell:—Progress is reported on Assignment No. 8, Progress Being Made by Federal and State Authorities on Regulations Pertaining to Railway Sanitation, collaborating with the Joint Committee on Railway Sanitation, A.R.A. This appears as Appendix F on pages 92 and 93. However, in the absence of the Chairman, Mr. VanHovenberg, I will present this report.

The report of the Joint Committee on Railway Sanitation was printed and distributed in November 1931, by the American Railway Association as Circular M&S 133.

Representatives of the Engineering and Mechanical Divisions, Medical and Surgical Section and of the U.S. Public Health Service and the Canadian Health Department collaborated in assemblying the material in this report, which is circulated for information only.

Considerable of the information presented was obtained by extensive original research by individual members of the Joint Committee, and the resulting suggestions in many instances will, if applied, lead to considerable operating economies for railroads, as well as improved sanitation.

The members of the Joint Committee on Railway Sanitation, representing the Water Service and Sanitation Committee of the American Railway Engineering Association, feel grateful for the privilege of rendering the service they have in behalf of the member railroads.

This report is submitted as information.

Vice-President W. P. Wiltsee:—It will be received as such unless there is some objection.

Chairman R. C. Bardwell:—Report on Assignment No. 9, which appears in Appendix G, is one of the first complete reports on sanitation matters which has been published by the Committee and contains some very valuable fundamental information on the troublesome question of sewage disposal, which is in line with best practice recommended by State and Federal health authorities. The Committee is indebted to Mr. W. P. Hale, Chairman of the Sub-Committee, for the considerable amount of work and study he has given this report.

In the absence of Mr. Hale, the report will be presented by Mr. H. F. King.

Mr. H. F. King (Erie):—The report covering "sewage disposal where sanitary facilities are not available" is given in Appendix G and will be found on pages 93 to 100 inclusive in Bulletin 349.

The question of sewage disposal is a troublesome one. Your Committee considers the assignment that of presenting for guidance of the railroads the various methods of

disposing of human waste where connections with sewage systems are not readily available. The various railroad systems traverse a wide territory and are therefore subject to Federal regulations, various state codes and many city and village ordinances and rules. Confusion develops in harmonizing the views of all concerned as a result of the above conditions. For these reasons, the adoption of system standards of practices are matters which present many complications, and no such standards, therefore, are recommended for the present.

Your Committee has endeavored to work out the most economical methods for disposing of this waste and still be in line with the best practices recommended by Federal and State health authorities. It is recommended that the report be received as information.

Vice-President W. P. Wiltsee:—Unless there is objection thereto it will be so received.

Chairman R. C. Bardwell:—That concludes the report.

Vice-President W. P. Wiltsee:—Are there any questions you would like to ask this Committee?

This Committee, gentlemen, is composed of experts in their particular line and they have presented to you a large amount of practical and useful data on this subject. They are relieved with the thanks of the Association (Applause).

DISCUSSION ON BUILDINGS

(For Report, see pp. 681–702)

(Vice-President W. P. Wiltsee in the Chair.)

Mr. A. L. Sparks (Missouri-Kansas-Texas):—The report of the Committee on Buildings will be found on page 681 of Bulletin 354. The Committee offers no recommended changes for revision of the Manual at this time.

Preparation of Specifications for Railway Buildings, appearing in Appendix A, page 682, will be submitted by Mr. F. R. Judd, Chairman of this Sub-Committee.

Mr. F. R. Judd (Illinois Central):—The Sub-Committee, or rather the Committee, offers at this time for adoption and publication in the Manual, Specifications for Hydraulic Elevators—Baggage or Freight. These specifications were previously published in the Proceedings as part of Appendix D, Section 28, pages 1215 to 1224, both inclusive, of Bulletin 323, and Vol. 31, Proceedings, 1930.

I move that these specifications be adopted for publication in the Manual.

Chairman A. L. Sparks:—I second the motion.

Vice-President W. P. Wiltsee:—It is moved and seconded that these specifications be adopted for printing in the Manual. Is there any discussion?

(The motion was put to a vote and carried.)

Mr. F. R. Judd (Illinois Central):—The Committee also submits for publication in the Manual, subject to revisions, Specifications for Steel, Brick and Reinforced Concrete Chimneys, with addenda for draft gages, pyrometer and lightning protection, all as previously published in the Proceedings as Appendix A, pages 406 to 424, both inclusive, of Bulletin 343, and Vol. 33, Proceedings, 1932.

The revisions are as follows:

"1. Steel Chimney Specifications, page 407, Unit Stresses, add the words 'lb. per sq. in.' after the unit stresses given in the table for concrete in compression and shear, also reinforcing steel in tension and bond.

"2. Reinforced Concrete Chimney Specifications, page 415, Unit Stresses, omit the words "lb. per sq. in." which appear after the ratio moduli of elasticity.

Insert after the words "Ratio moduli of elasticity," the words "for 2000 lb. concrete," and immediately below this line insert another line reading, "Ratio moduli of elasticity, for 3000 lb. concrete. . . 10."

I move that these specifications, with the revisions mentioned, be adopted for publication in the Manual.

Vice-President W. P. Wiltsee:—You have heard the motion. Is there any discussion?

(The motion was put to a vote and carried.)

Mr. F. R. Judd (Illinois Central):—In this Bulletin will be found Section 29, under Specifications for Railway Buildings, specifications for electrically-operated freight or baggage elevators. The Committee is submitting this for publication in the Proceedings, and it is hoped that we will receive criticism so that it can be offered for adoption at the next convention.

Vice-President W. P. Wiltsee:—The report will be so received.

Chairman A. L. Sparks:—Subject No. 3, Remodelling Freight Houses for Accommodation of Truck Door-to-Door Delivery of Freight, is shown as Appendix B. The Chairman of the Sub-Committee is not present, but the Committee has done considerable work on this subject and wishes to report progress.

On Subject No. 4, Bus Terminal Buildings, Isolated and in Conjunction with Railway Stations, Appendix C, we also wish to report progress.

For Subject No. 5, Application of Stainless and Rust Resisting Steels to Building Construction, Appendix D, we also wish to report progress.

On Subject No. 6, Vermin and Rat-Proofing Buildings, Appendix E, we also wish to report progress. We ask that these subjects be continued for further consideration.

Under Subject No. 7, Appendix F, Modern Methods of Heating Small Railway Buildings, Showing Comparative Advantages of Warm Air, Hot Water, Steam and Possibly Fan-Unit Systems, the Sub-Committee has requested that the Buildings Committee Chairman report on this in order to save time.

You will find considerable information, one pages 689, 690, 691, 692 and 693, covering this subject, which is offered with the hope that it will be useful in selecting the type of heating apparatus for various classes of railway buildings. It is offered as information.

Vice-President W. P. Wiltsee:—Are there any remarks on this subject? It will be received as information.

Chairman A. L. Sparks:—The report on Subject No. 8, Design and Construction of Modern Fruit and Produce Terminal Buildings, appears as Appendix G on page 694.

After considerable collaboration with the Committee on Yards and Terminals, which has a similar subject, this report is offered with the hope that it also will be useful to those who have occasion to design fruit and produce terminals, and it is offered as information.

Vice-President W. P. Wiltsee:—It will be received as such. Is there any discussion on this subject?

Chairman A. L. Sparks:—Subject No. 9, Relative Merits of Wood and Fireproof Roof Structures, which should include Wood, Hollow Tile Fireproofing, Concrete and Cement Tile, etc., page 699, appears as Appendix H. The Chairman of this Sub-Committee has also asked that the Chairman present this report.

There has been a great deal of work done on this subject and at our last Committee meeting there was so much information available that we had difficulty in determining just how much should be offered, so we ask that it be reassigned for another year.

Subject No. 10, Use of Materials Other than Brick, Stone and Cement in Exterior and Interior Walls, Partitions, Floors and Ceilings of Buildings with a View to: (a) Fire Resisting Qualities; (b) Less Space Occupied by Materials of Construction; (c) Better Heating Conditions; (d) Quieter Interiors; (e) Reduction in Size and Weight of Framework and Enclosures; (f) General Reduction in Cost of Construction, is shown as Appendix I, page 699. The information shown on pages 699 to 701, inclusive, is a sort of résumé of different types of building construction that have come into more or less common use during the last few years and that are being successfully used as substitutes for heavier construction. This is submitted as information.

Subject No. 11, Causes of Dust Explosions in Grain Elevators and Methods for Obviating the Hazard, is shown as Appendix J. Your Committee has formulated considerable information that can be used in making a very constructive report. We used some information from government bulletins and in submitting the information to the government for criticism, and to the officials who wrote the government bulletins, they asked for a little more time, so we should like to have this reassigned for further consideration.

That terminates our report, Mr. Chairman.

Vice-President W. P. Wiltsee:—There is one thing I noticed in this report. The Chairman stated at the end of his reports that he would like to have the subjects continued. It is a great help to the Outline of Work Committee for the Committee Chairmen to say whether or not they recommend subjects to be continued. This Committee is to be complimented on the very excellent report they have submitted and they are dismissed with the thanks of the Association (Applause).

DISCUSSION ON MASONRY

(For Report, see pp. 577–604)

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—The Masonry Committee presents its report in Bulletin 353, beginning with page 577. There was an unfortunate error in printing whereby there was omitted a figure or two in connection with Ballasted Deck Reinforced Concrete Trestle, which is printed in the Bulletin on page 588. You will find or have found leaflets to replace that figure printed in the Bulletin, beginning in the middle of the page, reading Section B.

The assignment to the Masonry Committee last year in Item 2 was changed from "Design" to "Specifications and Design," in order to cover a revision of the Manual to include specifications for concrete in buildings.

The material gotten up by Sub-Committee No. 2 on Specifications and Design is contained in the report of Sub-Committee No. 1, Revision of Manual.

The Masonry Committee's report consists of Appendices A, B, C, D and E, with progress reports on Subject Nos. 4, 5 and 6.

The first subject to be reported on is Revision of Manual, which is to be presented by Mr. Leonard, Chairman of the Sub-Committee.

Mr. J. F. Leonard (Pennsylvania):—The report known as Appendix A is in Bulletin 353, starting on page 577 and continuing through to page 579. In each case of shorter revisions, the present article is presented, together with the proposed article. In several of the cases, the length of the present article is such that to save in printing it was omitted.

Briefly, all of these revisions in the Manual are merely slight changes which developed in the course of our debate to bring our Manual up to present practices, and in view of the late hour, if the Chairman so agrees, I will omit reading these articles and revisions and present the subject-matter as a whole, moving it for adoption.

The President:—If there is no objection from the members here, Mr. Leonard, we would be very glad if you would do that. We could act on it as a whole and then pick out different proposed articles. We will go ahead and consider it as a group and then have comment on proposed articles or certain parts thereof.

Mr. B. R. Leffler (New York Central):—I am satisfied with the revisions except that I should like to talk about the last one, proposed article 64, at the bottom of page 578 and at the top of page 579.

Mr. J. F. Leonard:—I will read, then, if that is satisfactory, the present article and then I will read the proposed article.

Present Article 64: The general heading is Waterproofing. Under that is the title "General".

"Concrete required to be water-tight shall be made with strict adherence to all provisions in these specifications regarding the choice of materials, proportions, consistency, mixing, placing, protection and workmanship."

The proposed article 64 reads, with the same heading: "Concrete required to be watertight shall be made with strict adherence to all provisions in these specifications regarding the choice of materials, proportions, consistency, mixing, placing, protection and workmanship. The quantity of water used per sack of cement shall be the minimum consistent with workability and the requirements for placing."

Mr. B. R. Leffler:—The last sentence is the only one I have in mind. I think it was two years ago or one year ago when the Committee promised the Association a recommendation on the maximum amount of water permitted per sack of cement. I then turned over to page 594, on the care in concrete making, or words to that effect, where they brought out a very good point. I am referring to the bottom of the page, and also to page 596, Article 4.

Both of these last two articles that I am referring to are very specific on the amount of water that should be used per sack of cement. In view of those two articles, it seems to me that this last sentence of proposed Article 64 is rather weak: "The quantity of water used per sack of cement shall be the minimum consistent with workability and the requirements for placing." That weak clause is a perpetual source of disagreement between the contractor and the company's inspector.

In view of those other two articles I think this should be strengthened, either omitted or placed in some other part of the specifications with a rather rigid limitation on the amount of water per sack of cement, providing that the consistency must be reached not by varying the water but by varying the amount of cement and the relation between the coarse and fine aggregates.

I cannot bring myself to think that consistency or workability should depend upon the amount of water. That has been the great crime in concrete mixing. That is why we have poor concrete. Mr. Crosby had been trying to get workability by adding water. We ought to hit that hard.

I should like to see that last clause strengthened or place it in some other place in the specifications where it can be stated in strong terms.

The President:—Have you any suggestions for the last sentence?

Mr. B. R. Leffler:—My point is this: I would limit the quantity of water permitted to 6.5 gallons per sack of cement. I do not know whether the Association or the Committee will agree on that rigid requirement. I never would permit any more water

than that to a sack of cement, if I am going to obtain durability, and durability is dependent upon permeability, as these tests show.

The President:—What does the Committee have to say about it?

Chairman Meyer Hirschthal:—This question was a subject of discussion of this Committee, and because of the fact that there was a slight disagreement, because of various conditions under which watertight concrete is required, this omission was made in the revision of the Manual.

In mass concrete, which has to be watertight at times, there are different conditions, for instance, than in using 6-inch slabs between I-beams and 6-inch slabs between reinforced concrete T-beams. Personally, I would be in favor of 6 gallons as the minimum of water for concrete. If that is the result of the proposal by Mr. Leffler, if he says that should be the minimum, it would be perfectly agreeable to me to include that in this provision, with the permission of the convention.

Mr. B. R. Leffler:—Since the Chairman has expressed himself that way, he is only half a gallon below me, and I am glad to know that there was a good fight in the Committee on that point.

I think that it is time this Association take a positive stand on this sloppy concrete. We have plenty of data and plenty of statistical material and plenty of history based on actual experience. I am heartily in favor of placing a limit of 6.5 gallons on the quantity. I would not hesitate to go to 6 gallons, though I would be willing to accept 6.5 gallons.

The President:—Mr. Leffler, if I understand the Committee correctly, they are willing to go along with 6 gallons if someone would make an amendment to that effect.

Mr. J. F. Leonard (Pennsylvania):—I would suggest, if I may, that you prepare for the Masonry Committee a revision of this last sentence. I think that the Masonry Committee and yourself can get together and draft this Article in such a fashion that it will satisfy your criticism. In view of the fact that there were no others, we would so include it as a revision of this presentation, if that is agreeable with the Chairman.

The President:—Would you want to have the decision that it is to go in the Manual or to be carried over until next year?

Mr. J. F. Leonard (Pennsylvania):—To go into the Manual.

Mr. Robert H. Ford (Rock Island):—I hardly believe that this is in keeping with the practice of the Association unless it is in the nature of a progress report.

Mr. Leffler is right in principle but whether the proper amount of water per sack of cement is 6, 6.5 or 6.75 gallons, should be determined by the Committee after careful consideration of all relevant facts. It should not be an offhand decision merely for the purpose of reaching an agreement with a member speaking from the floor.

The President:—Do you wish to make an amendment?

Chairman Meyer Hirschthal:—I will withdraw Article 64 on the part of the Committee.

Mr. J. F. Leonard:—I will change, if I may, my original motion for adoption of Appendix A, to make a motion for the adoption of Appendix A with the exception of the proposed revision in Article 64.

Mr. T. L. Condron (Consulting Engineer):—This has been up for a long while and we know as much about it now as we will a year from now. Would it not be possible to hang up a flag at the end of the paragraph in the way of an additional sentence covering what we all have in mind?

I therefore would suggest, if it is the desire to make a motion to that effect, that the sentence be added: "In general, the quantity of water should not exceed 6 gallons per sack of cement."

There must be some leeway for such work, but that hangs up a notice and I believe covers it as best we can. If the Chairman thinks well of that he can introduce it.

Mr. B. R. Leffler:—I should like to ask if the Committee has examined any service tests. By that I mean, how does that asphalt plank behave in actual service? It has been in use, now, for almost ten years. We ought to be able to know about some of the service test results.

Mr. A. L. Sparks (Missouri-Kansas-Texas):—You will probably remember that last year the Buildings Committee had been assigned the subject of Reinforced Concrete Specifications for Buildings. In our attempt to submit such specifications, a similar objection was raised and we were overruled and the Committee did not offer separate specifications. As I understand it, the Outline of Work Committee gave this assignment to the Masonry Committee with the hope that the present concrete specifications would be revised so that they might include anything that was necessary for building specification work.

The present draft of the Masonry Committee's revisions of specifications has been submitted since our last meeting of the Buildings Committee. We have not had an opportunity to go over it together. We should like very much an opportunity to go over it together. I should like, particularly, to call attention to the importance of the remarks made by Mr. Ford in regard to carrying this subject over. There are a number of points that the Buildings Committee feels should have been given consideration in these specifications. Among them is the design of composite columns, either of structural steel shapes or cast iron enclosed in concrete with steel spirals or ties; second, long sections; third, requirements for fire protection; fourth, arrangement of reinforcement for offset columns; fifth, rib floor construction; sixth, unit stresses when wind loads are included; seventh, provision for openings in floors for elevators and stair wells; eighth, minimum thickness and variation of thickness with height of monolithic walls, together with reinforcement of same.

I should like to move that this subject be reassigned to the Committee for further consideration, with instructions to collaborate with the Committee on Buildings.

The President:—As I understand it, Mr. Condron's contribution was a suggestion and not a motion. Is that correct?

Mr. T. L. Condron:—Quite so, yes, sir.

The President:—Mr. Leffler, do you want to make any motion? The Committee is agreeable to taking back Article 64 and reporting on it next year.

Mr. B. R. Leffler:—As I understand the Buildings Committee's position on this matter, they have a lot of other points that they are not in agreement with the Masonry Committee on. For the time being, I do not think we are so much concerned with those points. They can be ironed out by reassignment. This question of the amount of water per sack of cement has nothing to do with the Buildings Committee or the Masonry Committee or any other committee, per se. It simply has something to do with good engineering practice, and surely this great Association ought to be able to give this bad concrete a big black eye. The way to do it is to limit the water content and not leave it open to continual argument between contractors and the company's inspectors.

I am in favor of Mr. Condron's suggestion. I think possibly 6 gallons is a bit strong. I would go to 6.5 gallons, but I would not stand on the difference. I second Mr. Condron's suggestion.

Chairman Meyer Hirschthal:—I will move that there be added to proposed Article 64 a sentence reading: "In general, the quantity of water shall not exceed 6 gallons per bag of cement."

The President:—You move that as an amendment?

Chairman Meyer Hirschthal:—That is a motion, yes, sir.

The President:—Is there further discussion?

(The motion was put to a vote and carried.)

Chairman Meyer Hirschthal:—Before you go any further, I should like to make a few remarks in answer to Mr. Sparks. We do not propose to make this the last revision of the Manual. We expect to revise this Manual continuously. This is a continuous assignment, and for Mr. Sparks' information I would say that the question of composite columns is very much alive, and also that there is a great disagreement as to methods of handling it. On all railroads, in the design of buildings, we have found great difficulty with the various building codes because of the stringent methods of application to that type of structure. We know we are wasting thousands of dollars in figuring the bearing values of columns, as they have to be figured according to the building codes. It is something that the Sub-Committee on Revision of Manual will get after when the Design Sub-Committee is through with that assignment.

Mr. J. F. Leonard:—Gentlemen, I now desire to withdraw the last motion which I made and substitute a new motion as follows:

I move the approval of Appendix A, as shown on pages 577, 578 and 579, in toto, with the addition of a sentence added at the end of Article 64, reading: "In general, the quantity of water shall not exceed 6 gallons per bag of cement."

Chairman Meyer Hirschthal:—I second the motion.

The President:—Is there any discussion or question on that?

(The motion was put to vote and carried.)

Chairman Meyer Hirschthal:—The report of Sub-Committee No. 2, on Specifications and Principles of Design of Plain and Reinforced Concrete, is contained in Appendix B, beginning with page 580. I had expected that Mr. Laird, Chairman of this Sub-Committee, would present the report, but as I do not see him on the platform I will make the presentation in his place.

This report consists of practically four parts. The first is the design for a ballasted deck reinforced concrete trestle with sections and details contained in Fig. 1 to 7, inclusive, which are shown in the leaflet which has been reprinted. This tentative standard for a ballasted deck reinforced concrete trestle is an outgrowth of an assignment that the Committee received two years ago for collaboration with Committee VII—Wooden Bridges and Trestles, on the comparative economy of timber and reinforced concrete trestles. Before going into the economy it was necessary to design the trestles, and Section B of this report is the result of the assignment. This is presented as information. The Committee asks for the continuance of this subject.

If agreeable to the Chairman, I shall proceed with the next assignment.

The President:—If there are no questions and no discussions, it will be so received.

Chairman Meyer Hirschthal:—Section B of this report, which was just read, has been acted upon. Section A is an assignment which the Sub-Committee on Design has made to itself of keeping up to standard improvements and practices in design of rigid frames. The Committee is not at present in position to present a design specification for rigid frame structures of reinforced concrete, but one of its members, Hardy Cross, has been kind enough to write a monograph which is included in Section A. This is also presented as information.

The President:—It will be received as such.

Chairman Meyer Hirschthal:—The subject of Arches, which had been reported on two years prior to this, was far enough advanced for a further report, but because of the fact that there was a slight disagreement as to the scope that the Committee should cover in this subject, we decided to report only progress on the subject of Arches.

Concrete specifications have been presented by Sub-Committee on Revision of Manual, which have just been voted on. This completes Assignment No. 2, Specifications and Principles of Design of Plain and Reinforced Concrete, and we ask that the subject be continued.

The President:—If there is no objection, the report will be accepted as requested.

Chairman Meyer Hirschthal:—The third subject that the Masonry Committee presents a report on is that of Progress in the Science and Art of Concrete Manufacture, contained in Appendix C. The subject matter will be presented by Mr. Walter, Chairman of that Sub-Committee.

Mr. L. W. Walter (Erie):—The report of this Sub-Committee, published under Appendix C, is presented as information. In it proper curing, as applied to concrete, is described as that control of moisture and temperature conditions surrounding the concrete after placement, that prevents or minimizes evaporation of contained mixing water and secures and maintains a favorable temperature throughout the curing period. In short, for best results, control temperature when and as needed, and at all times prevent the evaporation of water from the concrete during the curing period. Some ways and means to this end are suggested. The relative merits of various methods are, to some extent, a debatable matter, but on one thing we are all in agreement; that is, that curing is one of the most important single factors in obtaining the desirable quality of concrete, and that during the early curing period there is in many cases the most need for sufficient moisture in the concrete.

This is a short report, taking up only five pages in the Bulletin, and it is presented as information.

The President:—If there is no objection it will be so received.

Chairman Meyer Hirschthal:—The next assignment was Contact with Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. During the last year there has been a reorganization of this Joint Committee because of the fact that Professor Slater, the Chairman, died in the course of the year. Mr. Lindau, of the American Society of Civil Engineers, was elected Chairman, and Professor Richart, of the University of Illinois, representative of the Concrete Institute, was elected Vice-Chairman, and Mr. McMillan, of the Portland Cement Association, was re-elected Secretary-Treasurer. This is a progress report on that assignment.

On Assignment No. 5, Foundations, the Committee also had material in such shape as to present a tentative specification at the last meeting of the Masonry Committee, but unfortunately it could not be whipped into such form as to present a report for printing.

The same is true of Assignment No. 6, Tunnel Lining, which subject was revised by the Sub-Committee to read Tunnel Lining by Means of Concrete, and this specification was not in form to be presented by this Sub-Committee.

Assignment No. 7 is also a progress report.

Under Assignment No. 8 the Sub-Committee has a form of Specifications for Repairing Deteriorating Concrete for printing in the Manual. This will be presented by the Chairman of the Sub-Committee, Mr. A. C. Irwin.

Mr. A. C. Irwin (Portland Cement Association):—The specifications as proposed for printing in the Manual are found in Bulletin 353, on pages 596 to 598, inclusive. The specifications as now proposed will replace, if adopted, those now in the Manual occurring on pages 643 to 644, under the title Methods of Repairing Defective or Worn Surface of Concrete.

The beginning of these specifications was three years ago when the subject, Methods of Repairing Deteriorating Concrete, was assigned to the Committee.

The report on that subject will be found in Bulletin 332, page 340. That report covers, in general, the main causes of deterioration of concrete and discusses methods by which it should be repaired.

Last year the Committee presented tentative specifications for repairing deteriorating concrete and made a special request that the membership criticize them. In addition, certain individuals who were taking an interest in concrete were invited to criticize the specifications.

This year the specifications that were submitted last year as tentative have been rearranged and revised and are now offered for adoption and printing in the Manual.

If there is no objection to presenting them as a unit, without reading even the subheads, Mr. Chairman, I move that these specifications be adopted for printing in the Manual.

The President:—Is there any discussion?

Mr. B. R. Leffler (New York Central):—I am ready to adopt these except that I should like to talk about paragraph 9 on page 598. It is unnecessary to read the rest of them.

The President:—Do you want No. 9, on Curing and Protection, read?

Mr. B. R. Leffler (New York Central):—I should like to have the first paragraph read.

Mr. A. C. Irwin:—"The surface of all new concrete shall be kept from becoming dry for a period of at least seven days beginning immediately after placement except where high early strength concrete is used, in which case the curing period may be shortened as determined by the Engineer to that which will produce equivalent strength."

Mr. B. R. Leffler:—That appears a little weak in this way: It says, "the surface of all new concrete shall be kept from becoming dry." There can be a great deal of difference of opinion between the railroad company's inspector and the contractor. It might be that it rained all night long or during the day. The contractor might say that the concrete is wet, yet it would not be going through a very good curing process. We have had in the past quite a little experience in preparing concrete. That clause should be strengthened by requiring the concrete to be cured under water applied through a dripping process with a cover thrown over it so that the whole surface is constantly kept wet. That would be stating the quality to be desired in a positive way rather than in a negative way.

If you do not put it in the specifications as strongly as that the contractor is going to argue with you that it is good enough. Make it as strong as possible. The previous articles in this report have placed strong emphasis on the desirability of curing concrete properly. The way to cure concrete in the field is to cure it in the right way. The right way is to keep the work as nearly as possible under the conditions you have developed in the laboratory for curing it. Put it under the conditions that produce the desirable quality.

Mr. A. C. Irwin:—I will say that I am slightly surprised myself to see what the language is here. If the Committee is agreeable, I propose to change the first line of that paragraph to read as follows: "The surface of all new concrete shall be kept wet for a period of at least seven days beginning immediately," etc., as before. Will the Committee accept that change?

The President:—The Committee does. Is that agreeable to you, Mr. Leffler?

Mr. B. R. Leffler:—That is a step in the right direction.

The President:—Let us walk up to it. What is the rest?

Mr. B. R. Leffler (New York Central):—I did not get your point. I would specify that the surface has to be played upon by sprinkling water, a continuous sprinkling of

water. That can be easily done. We do that right along. To say the thing must be wet is stronger than to say it shall not be dry. We have to have a positive method of keeping this surface wet. A continual application of water is the usual thing, in the form of sprinkling apparatus.

Mr. A. C. Irwin:—The principal thing involved is that if the surface is wet it cannot be dry. There are other ways of keeping it from becoming dry besides sprinkling, and it is oftentimes practically impossible to keep a surface wet by sprinkling. There are many ways now proposed to cure concrete as cheaper and more economical methods than sprinkling. The surface may be kept wet either by preventing the contained water from getting away or by supplying moisture to that surface. I think that we certainly have made it strong enough when we say it shall be kept constantly wet.

The President:—Are you agreeable, Mr. Leffler, to the change in the first part of paragraph No. 9?

Mr. B. R. Leffler:—There was a statement made about not allowing the water to escape. I am not in accord with that. That was the trouble with the old sloppy concrete; it always had water in it and it was always getting water into it. You might have water in the concrete an inch and a half from the surface, and yet the outside of that inch and a half would not be properly cured. What we want is concrete that is just as dry as we can make it; and just as wet on the outside as we can make it in order to cure properly, not relying on any water inside of it. Too much water inside is bad.

Mr. A. C. Irwin:—I am afraid that this discussion may get rather involved because we are probably not talking about the same thing. I agree absolutely with everything that Mr. Leffler has said, and in regard to the amount of water used in the mixing, less water in mixing and more in curing might be a very good formula. Of the water that is in the mix, ultimately a portion of it will get out. What we want during those early periods of hardening, the critical period of concrete making, is enough water present for a continuous hydration and hardening.

The President:—Your motion was that this was to be recommended for publishing in the Manual, with a change in the first paragraph under No. 9, Curing and Protection?

Mr. A. C. Irwin:—Yes, sir.

The President:—Is there any further discussion?

Mr. B. R. Leffler:—I agree to the suggestion to put in the word "thoroughly" before "wet". I want to emphasize that point.

Mr. A. C. Irwin:—He wants it *thoroughly* wet.

The President:—We will give him that "thoroughly."

Mr. A. C. Irwin:—That is acceptable.

The President:—All in favor, with that change, will please say "aye"; contrary, "no." It is carried.

Mr. A. C. Irwin:—This replaces, as I said before, material already in the Manual and the recommendation of the Sub-Committee is that the subject be discontinued.

The President:—If there is no objection, it will be so arranged.

Chairman Meyer Hirschthal:—The next subject the Masonry Committee reports upon is shown as Appendix E, No. 9, Design of Expansion Joints Involving Masonry Structures. Mr. C. A. Whipple, Chairman of the Sub-Committee, will make the report.

Mr. C. A. Whipple (Chesapeake & Ohio):—Your Committee has collected from a number of carriers plans covering various types of expansion joints involving masonry structures to meet various conditions, and submits sketches Fig. 1 to 21, covering these types, which appear on pages 599, 600, 601, 602, 603 and 604, Bulletin 353.

Since the Bulletin has been published, the Committee has been advised that the expansion device which is marked Fig. 10 is a scheme for which patent is being applied for, but no patent covering other devices is known.

It is recommended that these be received as information and the subject be reassigned for further study.

The President:—If that is the case, shall we exclude Fig. 10 for the time being?

Chairman Meyer Hirschthal:—As it is a matter of information, and since that patent is applied for, I think we could include that in the printing.

The President:—It may help in the long run on the others, too. We may have it printed before they get their patent. Is there any question on this? If not, it will be so received.

Chairman Meyer Hirschthal:—That concludes the Masonry Committee's report for this year.

The President:—The Chairman and members of this Committee have some fight in them. I am glad they have. There has been quite a discussion for years. They have settled this water question. The Committee has done excellent work and they are excused with the thanks of the Association (Applause).

DISCUSSION ON GRADE CROSSINGS

(For Report, see pp. 647–679)

Mr. J. G. Brennan (New York Central):—The report of Committee IX is contained in Bulletin 354, page 647. Subject No. 1, Revision of Manual, Appendix A, will be presented by Mr. P. M. Gault, Chairman of the Sub-Committee.

Mr. P. M. Gault (Missouri Pacific):—The first assignment of this Sub-Committee is further study of the Proper Lighting of the Base of Signals where located in the Center of Highway.

It is the opinion of your Committee that no change should be made in the present standard, which is fully outlined in A.R.E.A. Bulletin, Vol. 33, No. 337, July, 1931, and also in Bulletin No. 1 of the Joint Committee on Grade Crossing Protection, A.R.A. Your Committee feels that either of the methods of illumination shown is sufficient.

It is recommended that this conclusion be received by the Association as information and that the Joint Committee on Grade Crossing Protection, A.R.A., be advised of the action taken.

Vice-President W. P. Wiltsee:—I am not going to take up much time in discussing this interesting subject, but I have agitated for several years the question of lighting of the base of wigwag or automatic signals in the center of the highway. The Committee, I am sure, has gone into the matter very thoroughly and they stand by their original recommendation which is to place the light up above the base. We have had a good deal of experience. We have had accidents with lights above the base and have found that a light was more effective right in the corner of the top of the base, at each corner, when installed in the center of the street.

The President:—Is there any other discussion?

Mr. P. M. Gault:—I will say for the Committee that we have considered various methods submitted for the lighting of the base of signals and there is no objection to having the subject continued for investigation of any new methods that may be proposed or developed.

The President:—As I understand it, the Joint Committee on Grade Crossing Protection has approved this. Is that right?

Mr. P. M. Gault:—They have.

The President:—And your motion was what?

Mr. P. M. Gault:—That it be received just as information.

The President:—If there is no objection, we will proceed.

Mr. P. M. Gault:—The next assignment of your Sub-Committee is Detail Plans of "Number-of-Tracks" Sign, both Painted and with Reflector Lenses.

Your Committee has cooperated with the Signal Section, A.R.A., in developing detail plans for the following:

1. Detail plans for the "Number-of-Tracks" sign, both painted and with reflector lenses, identified as A.R.A. Signal Section Detail Drawings Nos. 1644A and 1645A.

2. Detail plans of the crossbuck sign, both painted and with reflector lenses, for use in connection with flashing light or wigwag signals, identified as A.R.A. Signal Section Detail Drawings Nos. 1640A, 1641A, 1642A and 1643A.

3. Detail plans for the illumination of the "Stop on Red Signal" sign and the "Stop-When-Swinging" sign, by means of reflector lenses, identified as A.R.A. Signal Section Detail Drawings Nos. 1646A and 1648A.

4. Plan of Adapter Clamp and Details for Signs, identified as A.R.A. Signal Section Detail Drawing No. 1647A.

5. Plan of Reflector Crossing Signal Marker, identified as A.R.A. Signal Section Detail Drawing No. 1649A.

6. Plan of Details of Numerals for Track Signs, identified as A.R.A. Signal Section Detail Drawing No. 1650A.

I might say that there has been very close cooperation with this Committee and the Committee of Design of the Signal Section. Mr. Patterson, who is present today, was in charge of working up the details for both committees. It has been submitted to the Joint Committee of the A.R.A. for approval, and they have approved it.

It is the recommendation of your Committee that the above-described drawings be endorsed by the Association as standard, by reference. That is to say, we believe that it is unnecessary to print these in the A.R.E.A. Manual because they will appear in the Signal Section Manual and they will be available for everybody's use. We will save a little money that way.

The President:—And by reference it practically protects their use?

Mr. P. M. Gault:—That is right.

I should like to add also that these signs and drawings will supersede some similar material in the Manual at the present time.

The next subject is (c) Detail Plans of the Illumination of Highway Crossbuck Signs by means of Reflector Lenses.

Your Committee, in conjunction with the Signal Section, A.R.A. has developed detail plans for the illumination of this sign, by means of reflector lenses. They are shown on pages 650 and 651 of the Bulletin. The plans showing the details are submitted herewith on those pages.

The assembly is not shown mounted. It can be mounted on a wood or concrete pole with the aid of straight bolts or it can be mounted on a pipe mast with the aid of clamp shown on Signal Section Drawing No. 1647A, in the same manner shown for the 90-degree reflector crossbuck.

I call your attention to one thing on these signs and that is that the angle of the blade is shown as 50 degrees. I will have something to say about that later but it is necessary to show that angle as 50 degrees on this particular drawing because it also affects other dimensions which are shown. So the drawing is correct for a sign with an angle of 50 degrees.

It is the recommendation of your Committee that the above-described detail plans be adopted by the Association as standard, and I so move.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Mr. O. E. Selby (Big Four):—I think there is a good deal to be said on this subject, more than can be said in the limited time we have here. One thing I object to is the adoption of the plan as a standard. I understand the policy of this Association is not to adopt anything as standard but to adopt certain things as recommended practice to go into the Manual. This illuminated crossbuck sign is a new thing, and, by the rule of the Association, it should not be adopted for printing in the Manual without having appeared at least one year as information. I should like to have an opportunity to discuss this form of sign, dimensions and all, with the Committee. For that reason, if I am not out of order, I would move to have it submitted as information at this time.

Chairman J. G. Brennan:—The Committee was largely influenced by the need of an illuminated sign at outlying crossings in the country, where it is dark and where there is a certain amount of danger, the idea being that if such a sign were developed and used, it would greatly help to stave off elimination of a great many crossings where accidents have occurred, because the illuminated sign will be a much more efficient type of protection, especially at night.

In developing this sign, the Signal Section and the Sub-Committee of this Committee have gone into it very thoroughly and have made a great number of tests. They made tests at Roosevelt Field. A number of manufacturers exhibited this sign for the tests and it proved very effective. I think there is need for such a sign right now. I believe that by deferring adoption of this sign, either as a standard or as recommended practice, there will be a delay in the benefit to the railroads that would like to use it.

I wish to say a word of praise for the Signal Section, for the fine manner in which they co-operated in developing this sign and for their excellent work in developing the details and specifications for the illuminated signs to be used on the crossing signals.

Mr. Robert H. Ford (Rock Island):—I appreciate what Mr. Selby has stated. It is sound and in accord with the practice of this Association.

Illuminated signs are essentially a safety measure. Their use at crossings where the traffic justifies should result in lessening the requirements for expensive grade separations and would, therefore, result in corresponding savings to the taxpayers and railways.

There are many crossings where grade separation is in contemplation that could be adequately protected by the use of modern protective devices. The illuminated advance warning sign and the illuminated crossing sign are now almost a necessary part of these devices.

There is great need for uniform practice in this respect and formative action by this Association would be a great aid in this direction. I hope, therefore, that any motion to recommit will not prevail.

The President:—I am very glad to hear what Mr. Ford has said. This is something that has been studied in this convention for at least three years. They first started a very elaborate scheme or plan for the design of these depressed button signs. They modified them in cooperation with the railroads. These other agencies have come along, with more or less surprise to the railroads, and participated in regard to the installation of the signs as well as their upkeep, which is also a step forward. They have withdrawn, if the information I have is correct, especially for the time being, their requests for the elimination of a number of grade crossings.

Mr. A. H. Rudd (Pennsylvania):—The point that has not been touched on is that we use in a great many cases the automatic highway crossing signal. We all know

that you cannot see the ordinary crossbuck. We must use a flashing light or else separate the grade. A good many of us have illuminated crossbucks and thus save the expense of putting up other signals.

Mr. O. E. Selby:—I am thoroughly in favor of the reflector type crossbuck signs. I do not mean my remarks to be any reflection, if you please, on the use of such a sign. I am thoroughly in favor of it. As long as this picture is printed in the Proceedings, it is available and can be used. If it is not made standard or recommended practice at this time, I think the railways will suffer no injury by the Committee giving this more consideration.

The President:—Another thing, Mr. Selby, that I think we should take into consideration is that the Joint Committee on Grade Crossing Protection wish to have this printed in their report or proceedings, or in their Bulletin.

Mr. P. M. Gault:—The Committee has tested some of these signs in actual service at night. This is a very distinctive signal. Its crossbars can be seen long before the letters can be distinguished. In my opinion it is one of the most effective markers for railroad grade crossings that has ever been devised.

In the last analysis, a driver cannot protect himself at a railroad crossing unless he knows he is coming to a railroad crossing. If he wants to protect himself, all well and good; if he does not, it does not make any difference what you put up. This is going to help the careful driver.

Mr. E. H. Barnhart (Baltimore & Ohio):—The Committee tells us that they are not going to replace the sign that is in the Manual. I do not see anything in here to indicate what distance this proposed sign is above the surface of the highway. This is rather important.

Mr. P. M. Gault:—The sign can be mounted any height desired on wood or concrete or iron posts. The standard has not been affected in any way. The standard is already shown in the Manual. The thought of the Committee is that it would simply be a substitute when used for the wooden or iron crossbuck.

The President:—Do you know offhand just what height the crossbuck is above the surface of the highway?

Mr. P. M. Gault:—It would be shown in here.

The President:—You have stated that?

Mr. P. M. Gault:—The book says the height should vary to suit local conditions.

The President:—Is there any more discussion?

Mr. Benjamin Elkind (Erie):—The Committee intends to have the detail plan shown on the following two pages as standard and under 1-B intend to modify it by eliminating the 50-degree angle between the blades.

As the Chairman has stated, there are many dimensions that are contingent on that 50-degree angle. I do not believe that this drawing, for the purpose of the Committee, should be modified. A second drawing would show perhaps the optional method, depending upon the angle.

Mr. P. M. Gault—The design that was shown is for a 50-degree angle. If you are going to make the sign other than 50-degrees, a slight change in the dimensions of the bolt holes and the size of the letters or possibly the spacing of the letters may be desirable.

There was one other reason for the adoption of this sign. This sign at the present time, as Mr. Ford has pointed out, is being used in certain states. The manufacturers are anxious to start making these on some standard basis. They want to know what we want and if we can lead with a standard instead of trailing we will be able to save a little money on our purchases.

The President:—Are you ready for the question?

(The motion was put to vote and carried.)

Mr. P. M. Gault:—The next assignment is A.R.A. Signal Section Specification Nos. 15633 and 15533. This is shown as Exhibit B on page 674 of this Bulletin.

It is the recommendation of your Committee that the above mentioned specifications be endorsed by the Association as standard, by reference. I so move.

Mr. Robert H. Ford (Rock Island):—I second the motion.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Mr. P. M. Gault:—The next assignment is (b) Revision of Highway Crossing Sign, illustrated on page 65, A.R.E.A. Bulletin Vol. 33, No. 337, July, 1931, to omit the 50-degree angle shown between the blades.

It has been called to the attention of your Committee that most of the roads throughout the country are using practically the same crossbuck sign and if the A.R.E.A. Manual could be revised to eliminate the angle between the blades, the practice of the railroads generally would then conform to the A.R.E.A. standard (as revised), excepting in certain states where laws require variation in painting or otherwise.

It is the recommendation of your Committee that the 50-degree angle shown between the blades of the Highway Crossing Sign be eliminated.

That also carries with it the elimination of certain dimensions which are affected by the angle. I so move.

Mr. Robert H. Ford (Rock Island):—I second the motion.

The President:—Is there any discussion? Now, Mr. Selby, I believe you have something to say about the 50-degree angle.

Mr. O. E. Selby:—The elimination of the 50-degree angle on the ordinary wooden crossbuck sign is of no importance, but it is of considerable importance if we omit the angle on the reflector sign. The manufacturers are ready and anxious to manufacture these signs in quantity and, as the Chairman of the Sub-Committee has pointed out, it is necessary to know the angle in order to fix the dimensions of the sign and the spacing of the letters. For that reason, for the reflector sign, the angle should be fixed, and without going into discussion at this time I am in favor of a considerably larger angle than 50 degrees.

What I hope to suggest to the Committee by correspondence is an angle of about 74 degrees which makes the inclination of the blades to the horizontal the familiar and simple angle of 3-4-5. That leads to simplicity in all the dimensions and permits of shortening the sign seven inches, compared with the picture given in the Bulletin. It would therefore effect considerable economy and to my mind such a sign offers a more expressive warning.

The President:—Do you make a motion to the effect that the establishment of this angle be withdrawn for the time being?

Mr. O. E. Selby:—I think it would be all right to eliminate it, as proposed here, as applying to the crossbuck sign that is already in the Manual. Then the angle for the reflector sign can be taken up and worked out later.

The President:—Is there any other discussion?

(The motion was put to vote and carried).

Mr. P. M. Gault:—That is all.

Chairman J. G. Brennan:—On Subject No. 2, Economic Aspects of Grade Crossing Protection in Lieu of Grade Separation, Mr. G. P. Palmer, Chairman of the Sub-Committee, will present the report.

Mr. G. P. Palmer (Baltimore & Ohio Chicago Terminal):—Considerable time and effort have been devoted to the investigation and study of this subject during the past two years. The broad scope of the subject requires collection of a great amount of statistical and cost data and it has not been possible to reach a definite and final determination to date. Preliminary studies have been developed, involving comparative tables, etc. The information compiled to this time permits only a report of progress being made.

It is the recommendation of your Committee that the subject be continued and that the report be accepted as information.

The President:—If there is no objection, it will be so received.

Chairman J. G. Brennan:—On Subject No. 3, Laws, Regulations and Practices Governing Dimensions and Clearances Affecting Construction, Protection, Elimination and Separation of Grades of Highway Grade Crossings, the Chairman of the Sub-Committee is not here and I will present the report for him.

Information for this assignment was secured by means of a questionnaire which was distributed to the several state highway departments of the United States, the District of Columbia, and the Canadian provinces. Wherever possible, the legal requirements have been indicated in the tabulation, which is submitted herewith.

It is the recommendation of your Committee that the report be received by the Association as information.

The President:—This is a very valuable report. It gives you a geographical statement of conditions over the country. The Committee should be complimented on compiling this information.

If there is no objection, the report will be received as information.

Chairman J. G. Brennan:—Subject No. 4, Appendix D, covers Laws and Practices for Determining Division of Cost of Highway Grade Crossing Separations. Mr. M. V. Holmes, Chairman of the Sub-Committee, will present the report.

Mr. M. V. Holmes (Santa Fe):—Mr. President and Gentlemen: This report appears on pages 652 to 668 of this Bulletin and consists of abstracts of laws and practices in the various states governing the cost or division of cost of highway grade crossing separations.

Since this report has been printed we have received advice that makes a few corrections necessary.

Under Connecticut, on page 653, the first two paragraphs should be eliminated as that state has recently passed a law rescinding that action.

On page 655, under Maine, the percentages there have been corrected by legal statute. I will just read that: "Public Utilities Commission has authority to order grade separations and to apportion costs upon definite statutory percentages, 10 per cent to towns or cities, 40 per cent to state and 50 per cent to railroads."

On state highways division of cost is now being made on 50-50 basis.

On page 659 there is a correction under Vermont. The second paragraph should read: "When existing crossing eliminated railroad pays 50 per cent, state 40 per cent and balance municipality.

"Where new highway is established the railway pays 45 per cent, state 40 per cent, and the municipality the balance."

These same corrections also apply in the summarized statement at the end of the report.

This report is submitted as information.

The President:—This is another very vital report and it should be of very great interest in regard to possible changes in legislation we hope to accomplish.

Mr. Robert H. Ford (Rock Island):—I am not clear whether the findings in Appendix "D" apply in effect to the work of the Committee or to limitations placed upon them by the Board. The assignment states, "Laws and practices for determining the divisions of cost of highway grade crossing separations". The Committee might properly have reported their conclusions in one brief sentence, viz., "There are no such laws and practices", for this states the actual facts.

Unless the report of the Committee is qualified, it is open to misinterpretation. It leaves the impression that the laws in the majority of states provide a 50 per cent division of cost in grade separation cases. This would appear to be the case, but in practice it is not so.

Laws in most of these states operate in a sense as a club to compel railroads to go along with their highway programs. Actual division of cost, however, are matters of negotiation irrespective of the technical or legal provisions quoted by the Committee.

In some of the states listed by the Committee as having legal provisions for a 50 per cent division of cost, it is the practice to construe the provisions to enable the division to be made on the basis of 50 per cent of the cost of the structure. In others this is taken to apply to 50 per cent of the works on the right-of-way, etc., etc., the purpose in all cases being for public authority to work out a settlement with the railroads in order to avoid legal or other delays in the prosecution of public works, in which the spectre of a drastic application of the law can continue, if necessary, in the background.

The underlying principle of fairness and equity will ultimately be found within the realm of a scientific approach to these problems. This is essentially the province of the Engineer. Unless and until these things can be crystallized and promoted along lines of scientific research, the railroads will probably continue as they have in the past to be the victims of unwise legislation and unjust apportionments of cost, which in the end usually results in the waste of public funds and the dissipation of private funds. This obtains more readily by the ability of public officials to advance excessive and frequently unnecessary expenditures. Every Engineer within his experience can usually find typical examples in support of this latter statement.

From the background of many years' study and practical experience with this problem, I have become convinced that the development of guiding principles or formulas on such matters lies within the field of engineering research and not within the domain of politics.

I also believe that the fundamentals of the problem will be found in the principle of apportioning costs on the basis of benefits received rather than upon arbitrary methods whose only justification is their simplicity of application and understanding. I am hopeful that the work of the Committee for the ensuing year may be undertaken somewhat along these lines.

Vice-President W. P. Wiltsee:—I do not want to take up much time as it is getting late but I cannot resist the opportunity to praise the work of this Committee. The compilations or the summaries of the laws of the various states have a very practical effect. Less than a month ago, in fact, two days after this report came out, there was a bill introduced in one of the states in the eastern part of the country to increase the cost of the railroads' portion of grade elimination. I sent this Bulletin to our attorneys and it was presented to the members of the legislature and that bill was defeated. I cannot help but feel that that information in a practical way helps to reduce the cost of grade elimination work.

Mr. A. F. Blaess (Illinois Central):—I believe the remarks just made by Mr. Ford are sound in principle, and I merely wish to endorse what he has said.

Mr. E. R. Lewis (Michigan Central):—I agree with Mr. Ford.

Mr. A. N. Reece (Kansas City Southern):—I also wish to endorse Mr. Ford's comments.

Chairman J. G. Brennan:—In defense of this Committee I should like to say that the Committee has endeavored to follow out the assignment that was given to it by the Association. I agree with Mr. Ford on practically everything he has said. In fact, this Committee made a suggestion for the Outline of Work for this year along the line that Mr. Ford has been talking about. That suggestion was referred to the Joint Committee on Grade Crossing Protection and was turned down. It was the opinion that the time was not opportune to take it up now.

Subject No. 5 is Drainage Methods for Grade Crossing Elimination Projects and Division of Cost Chargeable thereto. In the interest of saving time, I will say that this is a progress report and it is a report that is recommended to be received by the Association as information.

It is the sense of this Committee that drainage methods for grade crossing elimination projects are engineering details to be considered in connection with each individual project.

Likewise, the division of costs chargeable thereto is a problem that must be determined as part of the division of cost of the entire project.

Subject No. 6, Use of Concave Street Sections for Grade Separation Subways and Transition from Crown to Concave Sections. Mr. E. R. Lewis, Chairman of this Sub-Committee, will present the report.

Mr. E. R. Lewis:—The Sub-Committee's report on No. 6 is found on pages 669 to 670 of Bulletin 354. I want to say only a few words about this subject which is really so old that it is new. The excavated streets of Pompeii are of concave cross-section. We have in Detroit two subways, one on a main thoroughfare, Woodward Avenue, built in 1901 with concave pavement cross-section. I do not think there are more than 100 people in that city who know that it is a concave section. The effect on traffic is little different from a convex section. There is an average traffic of 2500 cars an hour through this subway. I assure you that there is no reason anyone should hesitate to recommend the concave section wherever it is necessary to obtain increased vertical clearance.

The definition is given on page 669 and we have a line drawing on page 670, which is intended to show the transition from convex to concave cross-section.

The report is offered as information.

The President:—Does anyone wish to ask any questions? If not, it will be so received.

Chairman J. G. Brennan:—Subject No. 7 is Study and Recommend Standard Specifications for Street Crossings over Railway Tracks, both Steam and Electric. This is a subject that the Committee recommends be continued for further study and report.

The President:—If there is no objection, it will be so handled.

Chairman J. G. Brennan:—No. 8, Use of Highway Crossing Plank and Substitutes therefor, is also a subject which requires further study and report, and it is the recommendation of your Committee that the subject be continued.

The President:—If there is no objection it will be so handled.

Chairman J. G. Brennan:—Subject No. 9 covers Stock Guards—Types, Uses and Necessity. Mr. Maro Johnson, Chairman of the Sub-Committee, will present the report.

Mr. Maro Johnson (Illinois Central):—Mr. Chairman and Gentlemen: This report is shown on page 672. The conditions which formerly necessitated the placing of stock

guards at highway grade crossings no longer exist in a large part of the country and the use of stock guards is gradually being discontinued.

The report is submitted for information and it is recommended that the subject be discontinued.

The President:—Is there any discussion? In that same connection, the Outline of Work Committee will take cognizance of that and act accordingly.

Chairman J. G. Brennan:—I neglected to say, under Subject No. 8: "It is the further recommendation of your Committee that further study of this subject be conducted under the caption of "Study the Types and Relative Economy of Different Types of Highway Crossings, Collaborating with Committees I—Roadway, and V—Track."

The President:—The Committee on Outline of work will handle that subject.

Chairman J. G. Brennan:—That completes the report of Committee IX.

The President:—I wish I had time to express myself fully on the good work that this Committee has done in the past. I think that we can thank them for the work they are doing now and if we will use it we can save a great deal of money. We excuse the Committee with the thanks of the Association (Applause).

INDEX

A

B

C

D

E